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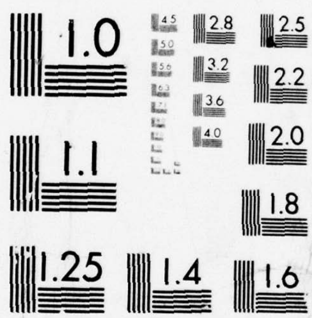

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THE SHOCK AND VIBRATION INFORMATION CENTER

Code 8404 Naval Research Laboratory
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DIRECTOR NOTES

The February 1977 issue of the Journal of the Acoustical Society of America contains a series of papers on the history of American Acoustics. The Society in general, and the authors in particular, are to be commended for an excellent contribution to our literature. I firmly believe that "the past is prologue" and that the history of science and technology has a strong influence on our present and future research. In this vein, as I looked at this fine journal, I wondered about the origin of scientific journals and how they have grown. Professor John Ziman, FRS, of the University of Bristol provided some interesting answers.*

It all began with the "Philosophical Transactions of the Royal Society" in 1665 which covered all branches of learning. As new learned societies were formed, each would start its own journal. By 1750 there were about 10 different scientific journals; in 1825 the number had grown to 300. Science was growing so rapidly at this point that researchers could not hope to scan all the literature and the first abstract journal was born. By 1950 there were 300 abstract journals covering material from more than 50,000 scientific journals. According to Professor Ziman, the number of journals is not the only indicator of strain on the system of communication since the bulk of each of these journals seems to double every 10 years. How can we continue to cope with this massive problem?

I agree with two statements in Prof. Ziman's book; ". . . the 'abstract journal,' where summaries of all new scientific papers are published under carefully classified headings, is quite an old device that is not easily improved on. . ." -- part of the contribution of our DIGEST is in this area. "Much more deliberate attention to writing of treatises and critical review articles would also help in opening up the archives and finding the nuggets of gold among the dross" -- our literature review section, as yet imperfect, is approaching the problem along these lines. It is hoped that in our field we will have a measure of success.

H. C. P.

*John Ziman, FRS, <u>The Force of Knowledge - The Scientific Dimension of Society</u>, Cambridge University Press, 1976.

EDITORS RATTLE SPACE

VIBRATION "POLLUTION"

Most engineers have been concerned with vibration as it pertains to the function and life of machines, vehicles, or structures. To date, little attention has been given to the effects of vibration on man. Men who work with vibrating hand tools and on ships can testify to the physiological and psychological effects of vibration . Although such physiological problems as pneumatic hammer disease and "dead finger" (Raynaud's phenomenon) have been recognized for some time, little effort has been made to establish the relationship between stimulus and effect. No attempt has been made thus far to assess the psychological effects of vibration on man, but environmentalists have stimulated interest in the matter.

Noise and vibration pollution are analogous. The physical effects of noise are evident as hearing loss; the physical effects of vibration "pollution" are probably less obvious, perhaps causing problems that are not immediately evident. The two types of pollution are of course connected: much airborne noise is attributable to mechanical vibration. If the vibration can be stopped, the noise stops. Excessive noise is often controlled by inserting barriers in the sound path -- the noise level drops, but the vibration continues. Such a solution is fine in situations in which men are not exposed to the vibrating object. In cases in which men are involved, however, the basic vibration problems remain. If environmental standards pertaining to vibration are eventually established, therefore, these problems will have to be dealt with again.

The public forced legislation to control noise pollution. Unfortunately, lack of coordination of efforts at all levels of government resulted in conflicting requirements. Voluntary standardization of noise levels was largely ignored by industry until the laws were in effect. As a result, both effort and money were wasted in superficial and temporary solutions aimed at complying with the various regulations. Will the same chaotic situation develop if vibration "pollution" regulations must be established?

The question of whether or not vibration "pollution" will have to be regulated has yet to be answered. A few voluntary programs at the national level (A.N.S.I.-S2) and the international level (ISO TC108) have been initiated by users in attempts to develop procedures and criteria for controlling vibration effects on man. To my knowledge no machinery manufacturers have attempted to incorporate human factors into machine design. Perhaps they are not yet aware of any problems. In my opinion it is time for manufacturers, as well as more users, to become involved in standardizing vibration "pollution." A strong voluntary effort in the near future might help us avoid possible regulatory confusion.

R. L. E.

DAMPING CAPACITY OF STRUCTURAL MATERIALS

J. Robert Birchak*

***Abstract** - Damping devices are frequently added to structures to prevent unwanted vibrations. Alternatively, structural materials with high internal friction sometimes provide sufficient damping. This review article surveys damping mechanisms that produce significant internal friction in structural materials. Damping capacity is presented as a function of vibrational stress amplitude for selected materials. Data from available literature are used to compare the relative dissipation of various mechanisms: viscoelastic relaxation, dislocation motion, two-phase interface slip, and magnetomechanical damping. These mechanisms have been used to reduce objectional vibrations in automotive disc brakes and in turbine blades.*

The energy of unwanted structural vibrations can be damped by internal friction within structural materials or by damping devices that contribute little to the load-carrying capacity of the structure [1, 2]. High-strength structural materials usually have relatively small internal friction; dampers are usually added to systems containing such materials to reduce objectionable vibrations. Certain high strength materials, however, have relatively high internal friction that can reduce vibrations. The purpose of this discussion is to review internal friction as a function of vibrational stress amplitude for a variety of structural materials. These data can be used in structural design to determine if internal friction will provide sufficient damping or if dampers must be added to control vibrations.

The references chosen from the extensive literature [3-6] on damping identify phenomenological mechanisms that contribute to the internal friction of structural materials. Some of the materials are already used to control vibrations...for example, graphite flakes are used in gray cast irons to eliminate "squeal" in automotive disc brakes [7], and magnetomechanical damping of nickel-cobalt alloys reduces vibrations in turbine blades [8]. The microstructure of manganese-copper alloys provides significant damping in selected applications [9, 10]. Damping in these examples is provided by internal friction within the load-carrying structural member.

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SPECIFIC DAMPING CAPACITY

The term damping coefficient must be defined before the internal friction from various phenomenological mechanisms can be compared. Damping is usually defined in terms of parameters that can be conveniently measured with a particular experimental apparatus. The definition is frequently based on the complex modulus of a damped harmonic oscillator that has coefficients independent of amplitude [11]. When internal friction is amplitude dependent, however, the complex modulus is not rigorously correct. Non-uniform stresses in the specimen make the interpretation even more difficult [1, 12].

For materials with amplitude-dependent damping, it is convenient to select a specific damping capacity, ψ. The specific damping capacity is defined as the fraction of energy lost per cycle in a body having a uniform distribution of stresses. If ΔU is the energy per unit volume dissipated per cycle and U is the maximum stored energy per unit volume,

$$\psi = \Delta U/U \tag{1}$$

Computer techniques have been developed for deriving ψ for bodies with non-uniform stresses [12].

For damping independent of vibrational stress amplitude, ψ can be related to the complex modulus. The two damping coefficients are related by the equation

$$\psi = 2\Pi \; E_2/E_1 \tag{2}$$

E_1 and E_2 are the real and imaginary modulii respectively. Equation (1) is used in the remainder of this discussion.

DAMPING MECHANISMS

General Categories

Damping mechanisms are frequently classed in one of two categories: relaxation phenomena and irreversible phenomena [1, 11]. The stress-strain cycle in both groups forms a hysteretic loop, the area of which is proportional to the energy lost per cycle. Relaxation phenomena generally involve rate-dependent dissipation of the energy; an example is resonant absorption. In resonant absorption the strain is out of phase with cyclic stress because of viscodrag. Viscodrag can be represented by a complex modulus [11]. Damping due to relaxation phenomena is usually frequency- and temperature-dependent; it is independent of amplitude, however. Because the effect is viscous in nature, the material relaxes to the original length when the stress is removed.

In contrast, a material that undergoes irreversible damping is permanently deformed after an applied stress is removed. A trace of residual strain remains after the stress is removed [1, 13, 14]. For cyclic stresses, the width of the hysteretic loop is determined from the residual strain. Damping due to irreversible phenomena is usually amplitude dependent and may be relatively independent of frequency and temperature.

A large number of damping mechanisms fall into one of these two categories. Many of the most extensively investigated mechanisms have only a small damping capacity. Electronic damping mechanisms, for example, produce only a small amount of damping and are of interest only at very low temperatures. However, the dissipation of vibrational energy in superconductors has been studied extensively to verify the existence of electron pairs proposed in the Bardeen-Cooper-Schieffer theory of superconductivity [15, 16]. Dissipation resulting from damping decreases as more pairs form because elastic waves are scattered by normal electrons but not by superconducting electron pairs. Because large amounts of damping are required to significantly reduce structural damping, the discussion below is limited to mechanisms that have a large damping capacity at typical operating temperatures.

Dislocations

Dislocations are disruptions of the orderly arrangements of molecules in materials and can be moved by applying stress [17-20]. Such stress-induced motion is dissipative; that is, energy is lost in the form of heat and elastic waves. Two types of motion occur; the dislocation is either pinned at its ends, and bends like a vibrating string, or breaks loose at the ends. The bending dislocation is a resonance motion that produces relaxation damping; the damping is dependent on temperature and frequency and independent of amplitude. The other type of dislocation produces a permanent residual strain; damping is relatively independent of temperature and frequency but dependent on amplitude. At high stress amplitudes, such irreversible damping can be a major source of damping in structural materials. Because the dislocation process depends on the microstructure of the material, materials must be carefully prepared to optimize damping.

Interface Slip

Materials comprised of two phases having dissimilar elastic properties can have damping due to slip (sliding of adjacent surfaces) at the interfaces between the phases. This sliding is irreversible and creates residual strains. In the damping of gray cast iron [7, 21, 22], for example, flakes of graphite precipitate in a matrix of metal. When gray iron is subjected to vibrational stresses, energy is dissipated at the interfaces between the graphite and the metal. Although damping increases with increasing concentrations of silicon and carbon in large flakes, the large flakes lower the strength of the iron. The composition of gray iron thus depends upon the specific application -- that is, whether or not damping or strength is most important.

Phase-Related Phenomena

Certain multiphasic materials other than gray iron, such as manganese-copper alloys [9, 10, 23], exhibit high damping capacities. The phenomenological origin of this damping is currently being investigated. Experiments have shown that these materials must specially treated with heat before their capacity for damping increases. For manganese copper, a high-temperature annealing process must be followed by

quenching and then aging at an intermediate temperature. This series of processes partially transforms the material into a tetragonal crystalline phase with a large damping capacity at room temperature. At elevated operational temperatures, both the damping and the amount of tetragonal phase decrease.

High Temperature Phenomena

Many materials develop a large damping capacity when the temperature approaches the softening temperature [24, 25]. The origin of such damping is attributed to various effects , including grain boundary motion, vacancy diffusion, and dislocation motion. Regardless of the origin, however, it is important to recognize that the damping at elevated temperatures may be significantly different from that at room temperature. Investigations by Postinikov [24] have shown that a variety of metals and alloys exhibit higher damping at elevated temperatures than at room temperatures.

Diffusion

The stress-induced diffusion of point defects (solute atoms, interstitials, and vacancies) produces relaxation damping [17, 26, 27]. Such damping is dependent upon temperature and frequency. Carbon and nitrogen in iron, for example, give damping maxima at temperatures of 22°C and 40°C at a vibrational frequency of 1 Hz. Wert [27] has found damping peaks as large as ψ = 0.1 for this diffusion damping in iron. Diffusion damping is usually not important in structural applications because it depends on heat treatment, decreases with age, and is often small. Diffusion damping has been investigated extensively, however, because it provides information on the atomic behavior of materials.

Magnetomechanical Damping

The stress-induced motion of magnetic domain walls produces irreversible damping [8, 12-14, 28-34]. The movement of magnetic domain walls in ferromagnetic materials occurs as a result of magnetoelastic interactions during the application of stress. The fractional energy lost per cycle has been related to the distribution of pinning centers that act as barriers to domain wall motion [32-34]. The resulting damping is dependent on vibrational stress amplitude and is influenced by magnetic field strength, static stress, temperature, and material microstructure. In a saturation magnetic field the domain walls, and hence magnetomechanical damping, disappear. The magnetomechanical contribution in this case can be identified independently of other damping mechanisms by subtracting the damping of the specimen in the saturation field from the damping in the demagnetized state. Magnetomechanical damping is also prevented by large static stresses that lock magnetic domains. Temperature dependence results from temperature-dependent magnetostrictive and magnetization constants. The effect disappears above the Curie temperature, which is the upper limit for ferromagnetism. Magnetomechanical damping, like most other damping mechanisms, is sensitive to microstructure and tends to be larger for annealed than for cold-worked materials.

DAMPING OF SELECTED MATERIALS

The relative effectiveness of damping mechanisms can be determined from the damping capacity of selected materials. Based on the definition in equation (1), the specific damping capacity, ψ, has been plotted against vibrational stress amplitude for various structural materials. The damping curves in Figure 1 are numbered for different materials. The properties of each material are identified by number in Table 1. Although the predominant mechanism for some materials with small damping capacity has not been identified in the referenced literature, these materials are presented to demonstrate the range of damping in structural materials. Most materials with a large damping capacity -- such as plastics, magnesium, and gray iron -- have relatively low tensile strength. Manganese-copper alloys, however, have relatively large damping capacity and high tensile strength.

Materials that exhibit magnetomechanical damping can also have relatively large damping capacity and high tensile strength. The damping curves in Figure 2 are numbered for materials having properties identified by numbers in Table 2. Curves labeled with a number followed by the letter "S" show damping in a saturated magnetic field. The magnetomechanical contribution is calculated by subtracting damping in a saturation field from damping in a zero field. Note that magnetomechanical damping has a maximum at a specific stress amplitude. The largest maxima are obtained for highly annealed specimens. Cold worked specimens have smaller maxima, but peaks occur at a

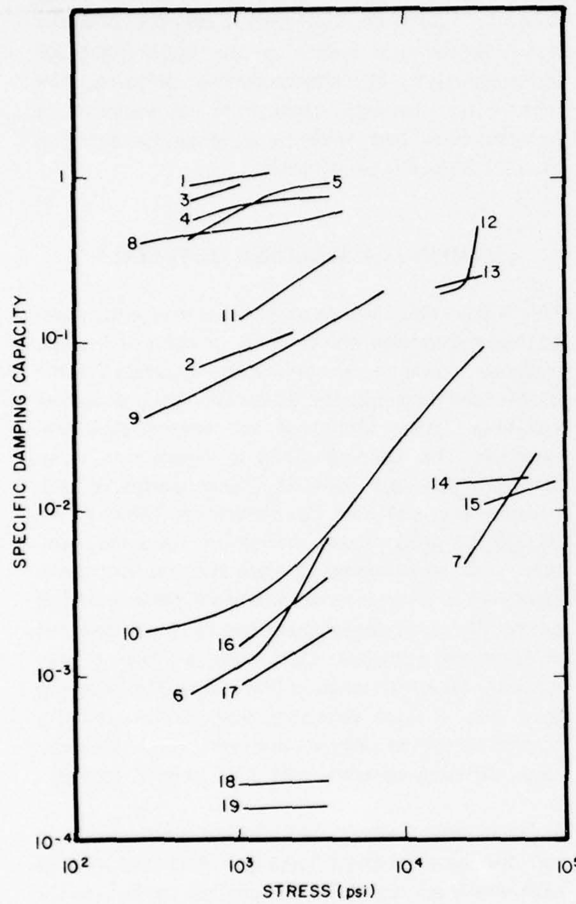

Figure 1. Damping vs. Stress Amplitude for Materials in Table 1

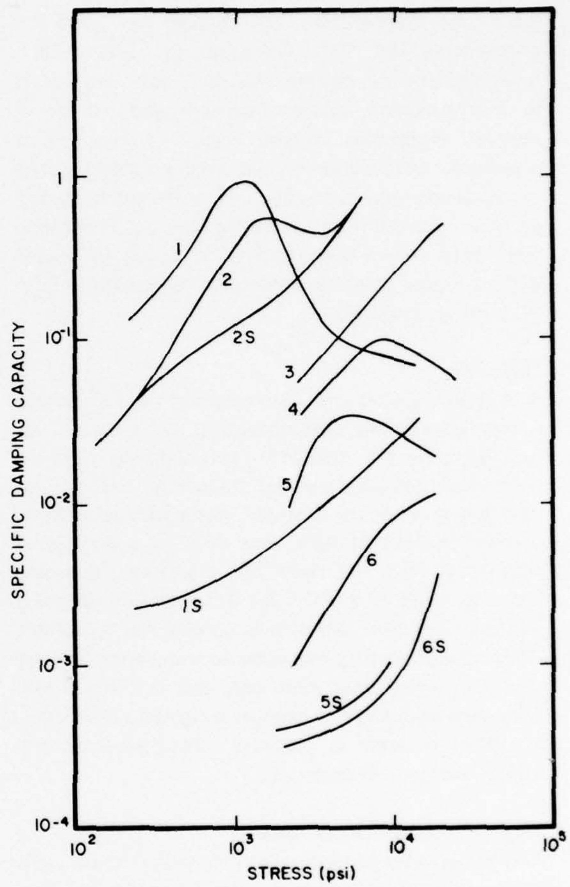

Figure 2. Magnetomechanical Damping vs. Stress Amplitude for Materials in Table 2

Table 1. Material Identification and Physical Properties for Damping Specimens

Sample Number	Material	Tensile Strength (psi x 10^{-3})	Damping Mechanism	Reference Number
1	Plexiglass	7 - 10	Viscoelastic	3
2	Polystryene	Not available	Viscoelastic	3
3	Cast magnesium 99.9% pure	10	Dislocation	20, 35
4	Mg - 0.6% Zn	21.6	Dislocation	20
5	Mg - 0.9% Mn	13.5	Dislocation	20
6	Mg - 8% A1, 0.5% Zn 0.2% Mn	52	Dislocation	20
7	Austenitic steel, Oil quenched from 1000°C, 16 hrs. 650°C	130	Dislocation	19
8	Pearlitic gray cast iron 3.63%C, 3.39% Si, 0.54% Mn	17.3	Graphite flake	7
9	Pearlitic gray cast iron 3.01%C, 2.49% Si, 0.53 Mn	41	Graphite flake	7
10	Pearlitic nodular cast iron	88	Graphite nodules	7
11	Mn - 35.9% Cu, 0.24% Fe, Heat 1 hr. 790°C, quench - 2 hr. 450°C	95	Two phase material	9
12	N-155 Alloy, Fe - 21.7% Cr, 1.9% W, 0.15% C, 19.4% Ni, 1.74% Mn, 19% Co, 0.76 Cb, 2.76% Mo, 0.37% Si quenched, aged	119(room temp.)	High temperature Damping (1500°F)	25

Table 1. Continued

Sample Number	Material	Tensile Strength (psi x 10^{-3})	Damping Mechanism	Reference Number
13	Stellite Co - 0.45% C, 1.4% Fe, 0.42% Mn, 24.8% Cr, 0.93% Si, 10.4% Ni, 7.26% W as cast	92.6(room temp.)	High temperature damping (1500°F)	25
14	Ti - 3.9% Al, 4.3% Mn, 0.1% C annealed	152(room temp.)	High temperature damping (600°F)	25
15	Sandvik Steel Fe - 1% Cr, 0.2% Si, 1% C, 0.26% Mn, 0.24% Mo, quenched, tempered	204	Not available	25
16	Free cutting brass Cu - 35% Zn, 3% Pb	55	Not available	20
17	A1 - 5.5% Cu 0.5% Pb, 0.5% Bi	53	Not available	20
18	A1 - 4% Cu, 0.5% Mg 0.5% Mn	62	Not available	20
19	Naval brass Cu - 39% Zn, 1% Sn	69	Not available	20

Table 2. Material Identification and Physical Properties of Specimens Having Magnetomechanical Damping

Sample Number	Material	Tensile Strength (psi x 10^{-3})	Damping Mechanism	Reference Number
1	Fe - 3.3% Si anneal 5.5 hr @ 1200°C	78	Magnetomechanical	12
1S	Sample 1 - Saturation Magnetic Field			
2	Pure Nickel	50-80	Magnetomechanical	13, 18, 31
2S	Sample 2 - Saturation Magnetic Field			
3	NIVCO 73.5% Co, 22.5% Ni, 1.8% Ti, 1.1% Zr	Not available	Magnetomechanical	1, 8, 25
4	403 Steel Alloy Fe - 12% Cr, 5% Ni	129	Magnetomechanical	4
5	Mild steel 0.28% C, 0.2% Si, 0.79% Mn, 0.12% Cu, 0.14% Ni, 0.1% Cr, annealed 18 hrs at 625°C	Not available	Magnetomechanical	14
5S	Sample 5 - Saturation Magnetic Field			
6	Carbon steel 0.42% C, 0.32% Si, 0.99% Mn, 0.09% Ni, 0.06 Cr, normalized	Not available	Magnetomechanical	14
6S	Sample 6 - Saturation Magnetic Field			

larger vibrational stress amplitude. Damping can be optimized, therefore, by selecting a heat treatment that produces damping maxima at the anticipated vibrational stress amplitude.

SUMMARY

Data from available literature show that structural materials can have significant internal damping capacity. Dislocation motion, two phase effects, and magnetomechanical damping give fractional energy lost per cycle as great as 0.5 or larger. The damping, however, depends on metallurgical microstructure; materials must be carefully prepared to obtain optimum performance.

ACKNOWLEDGEMENTS

The author appreciates the assistance of Dr. G.W. Smith and others at General Motors Research Laboratories in this literature review.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains the first parts of two serial articles. Professors Jensen and Madsen of the Department of Ocean Engineering of the Technical University of Denmark review the analytical and numerical tools for calculation of ship hull vibrations.

Dr. Chen and Dr. Pierucci begin to review underwater fluid-structure interaction technology.

A REVIEW OF SHIP HULL VIBRATION
PART I: MATHEMATICAL MODELS

J. Juncher Jensen and Niels Fl. Madsen*

Abstract - This paper is a review of the analytical and numerical tools used to calculate hull vibrations. Mathematical Models are described in the first part. The second part on Modeling of Physical Phenomena contains descriptions of mathematical models of the hull. Numerical determination of the equations of motion is discussed in the third part -- Methods of Solution. The fourth part, Comparison of Beam Models, is a review of methods used to solve the equations of motion; an example problem illustrates various principles.

Vibration is a serious problem in engine-powered ships. Vibrations of the hull are due to unbalanced moments and forces from the engine, the passage of the propeller through the irregular flow field, and wave-induced forces. Excessive hull vibrations give rise to local vibrations and noise, and may cause fatigue damage and operational problems in equipment or inconvenience to crew members and passengers.

The significance of hull vibrations is reflected in organizations and literature. Since its first meeting in 1961, the International Ship Structures Congress has had a subcommittee on ship vibration. The subcommittee publishes a literature review and a discussion of trends every three years [39-43]. Other reviews of various topics pertaining to ship vibration have been published [5, 7, 50, 69, 106, 115, 117], and a bibliography has been compiled [51]. Two books [91, 127] provide a thorough introduction to the subject and to the methods available up to about 1960.

Accurate determinations of the lower modes of ship hull vibrations can be made by modeling the hull as a single beam. The reason is that the length of a conventional ship is much greater than its linear cross section. Beam modes of vibrations can be divided into two types: coupled vertical-longitudinal modes and coupled horizontal-torsional modes. For higher modes of vibration, however, the single beam model is inadequate because distortions of the hull occur. Models suggested for analyzing higher modes range from two coupled beams to three-dimensional finite element models.

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VERTICAL VIBRATIONS

Vertical vibrations are usually more important than longitudinal ones because the vertical components of the exciting forces predominate. The coupling between vertical and longitudinal hull vibrations is usually neglected. Longitudinal vibrations play no significant role in either stress amplitudes or human discomfort.

The first mathematical treatment of the vertical vibrations of a ship hull was published by Schlick [113] in 1884. He modeled the hull as a Bernoulli-Euler beam with free-free boundary conditions and determined the fundamental two-node natural frequency. During the next 50 years the following phenomena were incorporated into the Timoshenko beam formulation [56] expressed in equation (1): virtual added mass of water [82, 124], shear deflection and rotatory inertia [17, 89, 105, 125], and damping [56, 125].

$$\begin{aligned} &\frac{\partial}{\partial x}\left[EI_V\left(1+\eta\frac{\partial}{\partial t}\right)\frac{\partial\phi}{\partial x}\right] + k_VGA\left(1+\upsilon\frac{\partial}{\partial t}\right)\left(\frac{\partial y}{\partial x}-\phi\right) - J_V\frac{\partial^2\phi}{\partial t^2} = -m \\ &\frac{\partial}{\partial x}\left[k_VGA\left(1+\upsilon\frac{\partial}{\partial t}\right)\left(\frac{\partial y}{\partial x}-\phi\right)\right] - (\rho A+\mu_V)\frac{\partial^2 y}{\partial t^2} - \alpha\frac{\partial y}{\partial t} = -f \end{aligned} \qquad (1)$$

EI_V and k_VGA are the vertical bending and shear rigidities respectively, ϕ is the slope due to bending, y is the total deflection, η and υ are internal viscous damping coefficients, and α is an external viscous damping coefficient; ρA, μ_V, J_V, f, and m are respectively the hull mass, the added mass of water, the mass moment of inertia, the external force and the external couple...all expressed per unit length. That equation (1) is suitable for the calculation of vertical vibrations with four to eight nodes, depending upon

the type of ship, has been verified in comparisons with full-scale measurements; see, for example, [3, 90, 95].

Single beam models have been used to derive semi-empirical formulas for determining natural frequencies. Formulas by Schlick [113] and Todd [126] have been used to calculate the fundamental mode for conventional ships. Accuracy improves with correction for distribution of loads and for hull stiffness variation [55, 61, 105], for shear deflections and rotatory inertia [54, 105], and for the effect of reduced water depth [105]. The importance of these formulas is decreasing, however, because digital computers are now used to obtain accurate solutions to equation (1).

Single beam models do not provide satisfactory descriptions of vibrations involving more than eight nodes because of local vibrations and shear lag effects. Local vibrations occur in such parts as bottom panels, side shells, longitudinal bulkheads, superstructures, and the shaft system; see, for example [50, 97, 107, 122]. The importance of the shear lag effect in horizontal members of the hull increases as the number of nodes increases [35, 36, 125].

The effect of bottom vibration is most pronounced for bulk carriers and cargo liners. In a study of the influence of bottom vibration on overall hull vibration, a model in which the bottom is treated as an isotropic plate and the remaining part of the hull is modeled as a shear beam was suggested [138]. The plate is hinged to the main hull along the bilge lines. In a refined version of this model [98] a Timoshenko beam was coupled with an orthotropic plate; the effect of the transverse bulkheads was included. Calculated modes of vibration were in accordance with full-scale measurements [98, 122]. Coupling between bottom vibrations and overall vibrations has also been analyzed with a two-beam model [115]. Another type of coupling is important in super tankers. The relative vertical deflections between the two longitudinal bulkheads and the side shells become significant with vertical vibrations having more than four to six nodes. This effect can be accounted for if the hull is modeled as two coupled Timoshenko beams [97]; the beams represent the side shells and the longitudinal bulkheads respectively.

The influence of the shaft system on hull vibration has been investigated [88]. The hull and the shaft system were represented by a uniform Timoshenko beam and a spring-mass system, respectively. The results pertained to the coupling between longitudinal and vertical hull vibration and shaft system vibration. Another model consists of a two-dimensional assemblage of beam elements, springs, and concentrated masses. An extensive parametric analysis using such a model has been published [50].

The disadvantage of two-dimensional beam and finite element models at higher vertical modes is that neither can account properly for the shear lag effect. The influence of shear lag has been studied with a simple rectangular box girder model [68, 104]. Although reliable results for higher modes are possible only with three-dimensional models [28, 35, 36, 107], the large number of parameters required with such models often destroys their usefulness.

HORIZONTAL-TORSIONAL VIBRATIONS

In conventional ships, the stiffnesses of the hull in horizontal bending and torsion are higher than those in vertical bending; furthermore, the forces that excite the horizontal-torsional vibration modes are relatively low. For these reasons horizontal-torsional vibrations are often ignored in the design phase of a ship. In ships developed in recent years, such as container ships and Ro-Ro ships, horizontal-torsional vibrations are just as important as vertical vibrations. The following coupled equations account for shear [96].

$$(EI_h\phi')' + k_hGA(y' - \phi) + \omega^2 J_h\phi = 0$$

$$[k_hGA(y' - \phi)]' + \omega^2(\rho A + \mu_h)(y + s\theta) = 0 \qquad (2)$$

$$(GK\theta)' + (J_t + \mu_t)\,\omega^2\theta + \omega^2(\rho A + \mu_h)\,s(y + s\theta) = 0$$

The natural frequency is ω. The natural modes are described by the bending slope ϕ, the athwartships deflection y, and the torsion angle θ, respectively; all modes are taken with respect to the shear center.

The distance between the shear center and the center of mass is denoted by s. Differentiation with respect to the longitudinal coordinate is represented by ( )'. Comparison of results obtained with equation (2) and with full-scale measurements reveal errors of ten percent in the natural frequencies. In addition, coupling between horizontal and torsional vibrations is lower than predicted. The model has been improved by accounting for warping rigidities and the effect of the transverse bulkheads [48]. Uncertainty as to the position of the shear center and the influence of the virutal added mass and mass moment of inertia means that results are not quite accurate. Forced vibrations have been treated with similar models [104, 114].

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INA: Institution of Naval Architects, London

RINA: Royal Institution of Naval Architects

JSNA: Journal of the Society of Naval Architects, Tokyo

RIAM: Research Institute for Applied Mechanics

BSRA: British Ship Research Associates

UNDERWATER FLUID-STRUCTURE INTERACTION
PART I: INTRODUCTION AND SCOPE

L.H. Chen* and M. Pierucci**

Abstract - Fluid-structure interaction encompasses a broad spectrum of technical areas of interest in engineering application. This discussion is limited to "underwater" applications and includes the following topics. sound radiation and scattering, structural vibration and shock response, flow-induced noise, hydrodynamic divergence and flutter, boundary layer stability, and propeller-induced forces. The common thread linking these technologies, namely, the interaction phenomenon, is stressed. An attempt has been made to clarify some of the terminology within these diverse technical areas.

This article focuses on the fluid-structure boundary (interface), specifically, upon the way in which the physically coupled phenomenon is being treated in engineering analysis. Nonlinear theory is not considered. Linear or linearized structural and fluid fields are implied.

The authors have taken advantage of several recently published review papers. References are cited to the extent necessary to support the text. Although many important works have not been included in the reference list, most of the relevant work is adequately covered in the review papers cited.

SCOPE OF REVIEW

A fluid-structure problem can be described by linear partial differential equations of the form

$$D_s[\overline{w}] = F(U) + P(\overline{w}^*) + F_A \qquad (1)$$

$$D_f[\overline{u}] = F(U) + P(\overline{w}^*) \qquad (2)$$

$$\overline{w}^* = \overline{u} \qquad (3)$$

D_s [ ] and D_f [ ] are differential operators that characterize the structure and the fluid medium respectively. U denotes the velocity of a moving medium. The vectors $\overline{w}$, $\overline{w}^*$, and $\overline{u}$ denote respectively the structural displacement, structural "particle" velocity at the fluid-structure interface. (Superscript * is used here to denote time derivatives.) The force field is represented by a linear combination of three components: F(U), which is due to the moving medium; $P(\overline{w}^*)$, which is the fluid interaction force field; and F_A, which represents all known or prescribed mechanical forces applied at the structure.

The complicating factor in a fluid-structure interaction problem is the interaction force field $P(\overline{w}^*)$. In this paper, the problems are placed in one of two categories, depending on the way in which $P(\overline{w}^*)$ is treated. Those methods which attempt to simultaneously satisfy equations (1) and (2) -- either exactly or in some approximate fashion -- are called formal or coupling, methods. Those methods which, by virtue of certain assumptions, require only the solution of either equation (1) or equation (2) are called decoupling methods. This paper covers three technical areas in terms of the nature of the applied forces -- either mechanical, acoustical, or hydrodynamic.

Mechanically-applied forces. The case of a structure *immersed in a stationary* (U = 0) inviscid fluid medium is considered; components $\overline{w}$, $\overline{w}^*$, and $\overline{u}$ normal to the fluid-structure interface are denoted by w, w*, and u respectively. The medium subjects the structure to periodic forces. Such problems are of interest in sound radiation and vibration of underwater structures when one or more harmonic forces is applied at any part of the structure. Equations (1), (2), and (3) take the form of

$$D_s[w] = p(w^*) + F_A \qquad (4)$$

$$\nabla^2 \phi + K^2 = 0 \qquad (5)$$

$$w^* = u \qquad (6)$$

The interaction pressure $p(w^*)$ is interchangeable with the force $P(w^*)$. Equation (5) is the fluid reduced wave (steady-state Helmholtz) equation in which ϕ is the potential; $K = \omega/c$ the wave number; ω the angular frequency; and c the acoustic speed of the fluid medium.

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$$p = -i\omega\rho\phi \text{ and } u = \frac{\partial\phi}{\partial n} \qquad (7)$$

In equation (7) the periodic time dependency of $e^{-i\omega t}$ is implied; ρ is the fluid density; and n is the outward normal at the fluid-structure interface.

Although formal and decoupling methods are considered separately, there is, in principle, no distinction between the two problems when fluid-structure interaction is considered. Decoupling methods have traditionally been employed almost exclusively in naval architecture for studies of ship vibration.

Acoustically-applied forces. Formal methods include both steady-state and transient cases; decoupling methods are also described. Acoustic scattering is essentially the "reciprocal" of sound radiation problems, and the same methodology applies. The two are considered separately primarily to emphasize the different ways in which the force field is traditionally treated in the literature. The problem of shock response, within the linear acoustic theory, is the same as that of transient acoustic scattering except that the response of the structure itself -- rather than the reflected or scattered acoustic field -- is of primary interest.

The steady-state case of acoustic scattering is governed by the same type of equations as that of sound radiation, see equations (4) - (7). The force field, however, may be conveniently separated into three components. Equation (4) is modified by

$$D_s[w] = \overset{i}{p} + \overset{s}{p}_1 + \overset{s}{p}_2(w^*) \qquad (8)$$

where $\overset{i}{p}$ represents the prescribed incident wave, i.e., the undisturbed wave that would be present if the structure were not there. The term $\overset{s}{p}_1$ represents the rigid scattering field, i.e. the induced acoustic field if the structure were assumed rigid ($w^* = 0$). The remaining term $\overset{s}{p}_2(w^*)$ denotes the elastic scattering field that accounts for the vibratory motion of the structure.

In the transient case of shock response, in which the structural response is of primary interest, the force field is usually broken up into two components. Thus, instead of equation (8), equation (9) applies.

$$D_s[w] = \overset{i}{p} + \overset{s}{p}(w^*) \qquad (9)$$

The interaction pressure $\overset{s}{p}(w^*)$ is sometimes called the scattered or radiated pressure.

Hydrodynamically applied forces (moving medium). Problems of interest are flow-induced noise, hydrodynamic divergence and flutter, boundary layer stability, and propeller-induced forces. Equations (1) - (3) take the form of equations (10) - (12).

$$D_s[\overline{w}] = F(U) + P(\overline{w}^*) \qquad (10)$$

$$D_f[\overline{u}] = F(U) + P(\overline{w}^*) \qquad (11)$$

$$\overline{w}^* = \overline{u} \qquad (12)$$

The fluid equation, equation (11), represents the linearized Navier-Stokes equation. The linearization process is a perturbation about the mean flow field velocity U. The linearization simplifies the nonlinear convective momentum terms; the viscous terms can be retained. The velocity-related forcing function F(U) can be obtained either analytically (as in flutter problems) or experimentally (as in turbulent boundary layer pressure fluctuation). In either case, F(U) is specified a priori, as is the case of F_A in equation (4) or $\overset{i}{p}$ in equations (8) and (9).

BOOK REVIEWS

DYNAMICAL SYSTEMS: STABILITY THEORY AND APPLICATIONS

N. P. Bhatia and G. P. Szegö
Springer-Verlag (1967)

This book is based on the lecture notes of the authors for courses meant for graduate students in mathematics, physics, and systems theory. Engineers will find the presentation somewhat abstract. Some knowledge of functional analysis and topological spaces is required. The format consists of definitions, lemmas, theorems, and their proofs. Few examples are included to illustrate the theorems, and there are few exercises.

The book contains three chapters. The first chapter, "Dynamical Systems in Euclidean Space," deals with the properties of elements constituting a dynamical system in Euclidean space...namely, trajectories, motions, invariant and minimal sets, and prolongations and their limit sets. The behavior of dynamical systems and stability concepts in the sense of Lagrange, Poisson, and Lyapunov are also described.

The second chapter, "Dynamical Systems in Metric Spaces," is more advanced. Properties of the elements comprising a dynamical system in metric space are presented. The behavior of dynamical systems with reference to stability in the sense of Lagrange, Poisson, and Lyapunov are described.

The last chapter, "The Second Method of Lyapunov for Ordinary Differential Equations," treats the existence and uniqueness of solutions of ordinary differential equations. Extensive results are given on the nonuniqueness of solutions. Several theorems on Lyapunov stability theory are stated and proved. A detailed list of references and a bibliography are given at the end of the book.

Engineers who have attempted to apply the Lyapunov stability theory to investigations of the stability of engineering systems will appreciate the enormous difficulties involved in determining suitable Lyapunov functions. There is no method for generating a Lyapunov function, even for systems described by linear ordinary differential equations, with time-varying parameters. Hence, for the present time at least, the theory has academic value only.

A. Frank D'Souza
Professor of Mechanical Engineering
Illinois Institute of Technology
Chicago, Illinois

CONCEPTS AND APPLICATION OF FINITE ELEMENT ANALYSIS

R. D. Cook

John Wiley & Sons (1974)

This book bridges the gap between existing finite element books, which emphasize basic theory, and the production computer, which furnishes "answers." The author states that his subject is analysis rather than design; his work is thus slanted toward general methods rather than special ones. Elements discussed in detail are based on an assumed displacement field and thus are not restricted to special shapes having no strain or curvature. Linear static analysis is emphasized, as are isoparametric elements.

In the first two chapters, the following topics are discussed: the basic elements of elasticity, plate and shell theory, interpolation and representation of curves applicable to grid meshes, Fourier representation of asymmetric loading conditions, and the application of the stiffness method to the plane truss. He also considers the assembling of matrices, establishment of the relationship between modal degrees of freedom, and a simple computer program of the Gaussian elimination method.

The physical reason for using the finite element method is to link small elements within a continuum. In chapters III and IV the author shows the similarity between finite difference and finite elements and considers plane and eight and 20 node solid-element isoparametric elements. He also establishes the validity of the isoparametric method and provides the order of the Gauss quadrature required to determine element stiffness.

The topic of chapters VI and VII is isoparametric elements, which behave poorly under bending. The author describes parasitic shear at the Gauss points. The situation with bending is improved by adding internal nodes and then condensing them before assembling the elements. This is important in three-dimensional eight-node brick elements. Incompatible modes have little effect on torsion and should be excluded for highly skewed elements. Solids of revolution under axisymmetric loading are two dimensional. The Fourier series is used for bending and torsion with such problems. The isoparametric relationship is useful for many types of asymmetric loading problems. The author describes specific and general cases for nonsymmetric loading.

In chapters VIII and IX the author describes an axisymmetric shell finite element program. He derives the stress-strain relationships and utilizes a curved element to formulate a segment of an element. He also derives a thin element for a flat plate. With regard to thick element (eight and 20 node) isoparametric elements, Gauss points are considered; the author recommends a 2 x 2 quadrature.

In chapter X on shell elements, the author recommends the 20 node element. A discussion of the advantages of the 2 x 2 quadration rule, which results in four upper and four lower Gauss points, is included.

Chapter XI contains a short description of coordinate transformation. The technique is used to apply material or element properties in different sets of coordinates and is important in orthotropic and isotropic shells. A short discussion of substructuring should have had greater emphasis.

Chapter XII considers dynamics and vibration. The eigenvalue problem, the Sturm sequence method, eigenvalue economizer, Gauss elimination method, and effective combinations of the methods are described. The SOLID SAP program is an example.

Chapters XIII through XV contain information about the stability of beam and plates; geometric stiffness matrix, nonlinearity behavior and large displacement of structures; deformed systems; and the Newton-Raphson method of iteration.

The final chapters contain information about hybrid, skew, triangular, and annular elements.

The reviewer considers this book outstanding but would have liked a more extensive discussion of dynamics, of geometrical stiffness applied to blades rotating in a centrifugal field, of mesh generation, and also a discussion of interaction graphics. The book contains an excellent bibliography.

H. Saunders
General Electric Co. - LSTGD
Schenectady, NY 12345

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

MECHANICAL FAILURES PREVENTION GROUP SYMPOSIUM ON DETECTION, DIAGNOSIS, AND PROGNOSIS May 17-19, 1977

The 26th Meeting of MFPG will be held at IIT Research Institute, Chicago, Illinois on May 17-19, 1977 under the sponsorship of the National Bureau of Standards, Office of Naval Research, Naval Air Development Center, Frankford Arsenal, Federal Aviation Administration, and the Energy Research and Development Administration, NASA, and hosted by the DD&P Technical Committee and IITRI.

The purpose of this symposium is to aid communications between those involved with the reduction of mechanical failures through detection, diagnosis, and prognosis with a basic theme of "DD&P Pay-Off". The meeting will consist of five technical sessions addressing (1) Oil Analysis Revisited, (2) Signature Analysis Techniques, (3) New DD&P Techniques and Equipment, (4) Railroad System Diagnostics, and (5) Land Vehicle Diagnostics.

General inquiries regarding the 26th meeting program should be directed to:

Mr. Henry H. Hegner, Program Chairman, GARD, INC., 7449 North Natchez Avenue, Niles, IL 60648 (312) 647-9000 or Mr. Robert M. Whittier, Publicity Chairman, Endevco, Rancho Viejo Road, San Juan Capistrano, CA 92675, (714) 493-8181

ENGINEERING FOUNDATION TO HOLD CONFERENCE ON "APPLICATION OF NEW SIGNATURE ANALYSIS TECHNOLOGY" July 24-29, 1977

The Engineering Foundation will hold a conference on the Application of New Signature Analysis Technology at Franklin Pierce College, Rindge, New Hampshire, July 24-29, 1977. This conference will be co-sponsored by the Vibration Institute. The program includes both panel discussions and formal paper sessions. Topics to be discussed include selecting a signature analysis system, application of new and novel techniques, future user's needs, industrial and OEM application of signature analysis, how to get started in monitoring machinery with signature analysis, and troubles and realities of signature analysis.

For more information contact Dr. Sanford S. Cole, Director Engineering Foundation Conferences, 345 E. 47th St., New York, NY 10017, (212) 644-7835 or Dr. Larry D. Mitchell, Chairman, Engineering Foundation Conference - Signature Analysis, Dept. of Mechanical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061 (703) 951-6750

CALL FOR PAPERS

48th SHOCK AND VIBRATION SYMPOSIUM*

The 48th Shock and Vibration Symposium will be held at the Von Braun Civic Center, Huntsville, Alabama on 18, 19, and 20 October 1977. The U.S. Army Missile Research and Development Command, Huntsville, Alabama is the host for this meeting.

SUBMISSION OF PAPERS

Those wishing to offer formal full-length papers for the symposium should carefully follow the instructions on the reverse side of the SUMMARY COVER SHEET. Papers may be offered either for presentation at the Symposium, or publication in the Bulletin, or both. Summaries of papers accepted for presentation will be published and distributed prior to the Symposium. Six copies of the two page (approximately 600 words) summary should be sumbitted. No figures should be included in the summary. Prospective authors are encouraged to submit supplemental figures and additional information which the program committee can use to evaluate the paper, but this material should not be referenced in the summary which will be published if accepted. Authors are required to furnish such a summary even if the complete paper is submitted. In general, unclassified-unlimited distribution summaries of classified papers are requested. If this is impossible, a classified summary may be submitted, but this will not be published. Deadline for receipt of summaries is 30 June 1977.

CLASSIFIED SESSIONS

The Shock and Vibration Symposium provides a special platform and publication medium for authors of classified papers up to SECRET. To simplify problems of paper release, SVIC policy for the 48th Symposium is that attendance at classified sessions will be limited to U.S. citizens having the required clearance and need-to-know. Limited distribution papers which are accepted will probably be programmed in the classified sessions.

SHORT DISCUSSION TOPICS

Because of continued interest, a session will once again be programmed covering progress reports on current research efforts and unique ideas, hints and kinks on instrumentation, fixtures, testing, analytical short cuts and so forth. It is intended to provide a means for up-to-the-minute coverage of research programs and a forum for the discussion of useful ideas and techniques considered too short for a full-blown paper. These discussions will not be published. Presentation of a short discussion at this meeting will not prevent later publication of the final results in SVIC publications or other journals. Accepted speakers will have 5 minutes for presentation and 5 minutes for discussion. Only unclassified-unlimited distribution discussions will be programmed for this session. Those interested only need to submit a short summary due at SVIC on 12 September 1977.

SUGGESTED TOPIC AREAS

Papers from all areas of shock and vibration technology will be considered. The following are possible topics for discussion based upon suggestions from the shock and vibration community.

- Ground Motion
- Ship Shock and Vibration Problems
- Numerical Methods in Structural Dynamics
- Reliability Testing and Field Failures
- Dynamic Testing and Environments
- Shock and Vibration Software
- Transportation & Packaging
- Instrumentation & Data Analysis
- Biomechanics
- Structural Response Analysis
- Rotor Dynamics & Balancing
- Vehicular Crashworthiness

CRITERIA FOR ACCEPTANCE

Papers will be evaluated on technical merit. They should describe work that advances the technology and which has not been published previously. Papers with a commercial flavor will not be accepted, however technical submissions from vendor employees will be judged without bias and on the same basis as those of other prospective authors.

PUBLICATIONS

For your scheduling, if your paper is offered for publication, three review copies of the complete paper, neatly typed in your own format, must be in this office by 12 September 1977. If the paper is accepted for publication, an author's kit will be provided for final copy preparation. Acceptance for publication in the 48th Bulletin depends upon favorable referee review.

LADIES PROGRAM

Arrangements are once again being made for outside activities for the ladies in Huntsville. Details will be included with the Advance Program.

PROGRAM

The advance program for the Symposium will be distributed in September, together with hotel, security clearance, and registration information.

*Forms enclosed in this issue of the DIGEST

SHORT COURSES

MAY

TURBOMACHINERY BLADING SEMINAR

Dates: May 3 - 5, 1977
Place: Rochester Institute of Technology
Rochester, New York

Objective: To introduce the vibration technology involved in the design and operation of turbomachinery blades. Methods and instrumentation used to measure and analyze blade vibration will be described. Industrial experts and consultants will present theoretical background material and case histories. Panel sessions dealing with gas and steam turbine blading problems and their solutions will also be conducted.

Contact: Dr. R. L. Eshleman, Director, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 Tele. (312) 654-2254/654-2053

FINITE ELEMENT METHOD AND NASTRAN USAGE

Dates: May 16 - June 9, 1977
Place: Washington, D.C.

Objective: A sequence of three professional development courses will be presented to provide an understanding of the technological content in general purpose finite element programs; and to provide training in the use of NASTRAN. The courses and dates are:

- Theory of Finite Elements, May 16-20, 1977
- Static Structural Analysis using NASTRAN, May 23 - 26, 1977
- Dynamics and Nonlinear Structural Analysis using NASTRAN, June 6 - 9, 1977

Contact: Dr. H. Schaeffer, Schaeffer Analysis, P. O. Box 761, Berwyn Station, College Park, MD 20740 Tele. (301) 721-3788

JULY

THIRD INTERNATIONAL OCEAN ENGINEERING AND MANAGEMENT COURSE

Dates: July 11 - 22, 1977
Place: UCLA Campus, Los Angeles, California

Objective: To provide an annual educational forum for technology transfer between engineering and management working in the field of ocean technology development.

Contact: Ocean Engineering and Management Course, 6266 Boelter Hall, UCLA Extension, Los Angeles, CA 90024 Tele. (213) 825-3858

INSTRUMENTATION FOR MECHANICAL ANALYSIS

Dates: July 25 - 29, 1977
Place: University of Michigan, Ann Arbor, MI

Objective: Emphasis is on the use of instruments by non-electrical engineers to analyze systems. Attendees will use a wide range of transducers and associated instrumentation. Morning lectures are devoted to theory and afternoons to various applications in the laboratory. Previous instrumentation experience is not required.

Contact: Engineering Summer Conferences, 200 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, Va., 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM). 313 N. Fir St., Ann Arbor, MI. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

77-648

Vibration of Branched Torsional Systems with Multiple Junctions

S. Mahalingam
Dept. of Mech. Engrg., Univ. of Sri Lanka, Peradeniya, Sri Lanka, J. Sound Vib., 49 (2), pp 195-214 (Nov 22, 1976) 4 figs, 11 refs

Key Words: Branched systems, Torsional vibration

The displacement excitation method is used to investigate the vibration characteristics of branched torsional systems with multiple junctions. Among the special features of the paper are the employment of the product form of receptances as an analytical tool and the use of overlapping subsystems in synthesis. The distribution of natural frequencies and the effects of changes in some of the parameters are discussed. A detailed numerical analysis is given for free and forced vibration of a two-junction system in which three of the natural frequencies are equal.

77-649

A Simultaneous Iteration Algorithm for Symmetric Eigenvalue Problems

R.B. Corr and A. Jennings
Ove Arup and Partners, London, England, Intl. J. Numer. Methods Engr., 10 (3), pp 647-663 (1976) 12 refs

Key Words: Eigenvalue problems, Iteration

A FORTRAN IV algorithm is presented for determining sets of dominant eigenvalues and corresponding eigenvectors of symmetric matrices. It is also extended to the solution of the equations of natural vibration of a structure for which symmetric stiffness and mass matrices are available. The matrices are stored and processed in variable bandwidth form, thus enabling advantage to be gained from sparseness in the equations. Some of the procedures may also be used to solve symmetric positive definite equations such as those arising from the static analysis of structures loaded within the elastic range.

77-650

Non-Linear Vibrating Systems in Resonance Governed by Hyperbolic Differential Equations

G.N. Bojadziev
Dept. of Mathematics, Simon Fraser Univ., Burnaby, British Columbia V5A 1S6, Canada, Intl. J. Nonlinear Mech., 11 (6), pp 347-354 (1976) 6 figs, 8 refs

Key Words: Asymptotic approximation, Differential equations, Natural frequencies

The asymptotic solutions of second order hyperbolic differential equations with weak non-linearities in the case of internal and external resonance are found. The method used is an extension of the Krylov-Bogoliubov-Mitropolskii method. An application is made to the longitudinal vibrations of a rod in which non-linear elastic behavior and linear viscoelastic damping occur.

77-651

On the Asymptotic Approximations of the Solutions of a System of Two Non-Linearly Coupled Harmonic Oscillators

A.H.P. van der Burgh
Dept. of Mathematics, Imperial College of Science and Technology, London SW7 2BZ, England, J. Sound Vib., 49 (1), pp 93-103 (Nov 8, 1976) 6 figs, 9 refs

Key Words: Oscillators, Asymptotic approximation

A procedure, closely related to the averaging method, is given for the construction of asymptotic approximations for the solutions of a Lagrangian system.

77-652

First Passage Probability for Nonlinear Oscillators

J.B. Roberts
School of Engrg. and Applied Sci., Univ. of Sussex, Falmer, Brighton, Sussex, England, ASCE J. Engr. Mech. Div., 102 (EM5), pp 851-866 (Oct 1976)

Key Words: Oscillators, Failure analysis, Probability theory

An approximate method of calculating the probability that a nonlinear oscillator will fail within a specified interval of time is developed, where failure is assumed to occur at the instant the response amplitude first exceeds a critical level.

It is shown for oscillators driven by white noise that the energy envelope of the response process is well represented as a one-dimensional Markov process. From the appropriate Fokker-Planck equation of this process simple differential equations for the moments of the time to failure are derived, and integrated numerically in certain cases. In the case of an oscillator with linear damping but a nonlinear spring of the power law type, a complete analytical solution is found in terms of hypergeometric functions.

77-653

Free Vibration and Steady-State Response of a Nonlinear Oscillator with Hysteresis

K.E. Boatright

Ph.D. Thesis, Univ. of Arkansas, 102 pp (1976)

UM 76-26,456

Key Words: Oscillators, Hysteretic damping, Computer programs

A different nonlinear hysteretic model as a mechanism for the restoring force and energy dissipation in an oscillator is proposed and investigated in this dissertation. The proposed model is referred to as a binonlinear hysteretic model of the cubic type. By proper selection of parameters for such a model, it may better simulate the dynamic response of some physical systems than do other dissipative models currently available. Direct and numerical integrations are used to obtain the solutions for the response of free vibrations. The method of equivalent linearization and an alternative method, the method of slowly varying parameters, are employed to obtain the equations of the steady-state forced vibrations.

OPTIMIZATION TECHNIQUES

77-654

Mechanical Design Optimization for Transient Dynamic Response

M. Hsiao

Ph.D. Thesis, The Univ. of Iowa, 109 pp (1976)

UM 76-26, 292

Key Words: Optimization, Steepest descent method, Transient dynamic response, Vibration isolators, Suspension systems (vehicles)

In this thesis, a technique for mechanical design optimization with constraints on transient dynamic response is developed through application of optimal design theory and functional analysis. Cost and constraint functions involving the state variables, design parameters, and environmental parameters are first formulated as extreme value functionals. The cost function is linear combination of extreme dynamic responses of the mechanical system and constraints are imposed on certain extreme responses.

FINITE ELEMENT MODELING

(Also see Nos. 679, 703, 768, 771, 830)

77-655

Solution Techniques for Linear and Nonlinear Dynamics of Structures Modeled by Finite Elements

H. Adeli-Rankoohi

Ph.D. Thesis, Stanford Univ., 345 pp (1976)

UM 76-25,965

Key Words: Finite element techniques, Nonlinear systems, Linear systems

Several competitive solution techniques for linear and nonlinear dynamic analysis of structures by the finite element method were studied. The accuracy, stability, and efficiency of the solution procedures were examined by comparing the results from a plane stress sample problem. For linear analysis four solution techniques were compared. They are direct linear extrapolation with the trapezoidal rule, the central difference predictor, two cycle iteration with the trapezoidal rule, and the normal mode method. Among the methods studied, direct linear extrapolation with the trapezoidal rule appears to be the best technique for linear dynamic analysis. The central difference procedure should be rated second, and two-cycle iteration with the trapezoidal rule is third. The normal mode method is competitive with the other methods studied only if modal truncation is used. For nonlinear analysis, three explicit methods and three implicit methods were investigated. Both material and geometric nonlinearities were included in the finite element formulation.

MODELING

(Also see No. 698)

77-656

Modeling of Vibrating Systems - An Overview. Part I. Force Balance and Energy Methods

A.J. Hannibal

Lord Kinematics, 1635 W. 12th St., Erie, PA 16512, Shock Vib. Dig., 8 (11), pp 25-29 (Nov 1976) 2 figs, 15 refs

Key Words: Mathematical models, Energy methods, Reviews

A number of prominent modeling methods are presented in capsule form. The "type" of modeling technique is emphasized rather than details of the method. The references have been divided into sections relating to the modeling methods.

PARAMETER IDENTIFICATION

77-657

Structural System Parameter Estimation by Two-Stage Least-Squares Method

W. Gersch, G.T. Taoka, and R. Liu

Univ. of Hawaii, Honolulu, Hawaii, ASCE J. Engr. Mech. Div., 102 (EM5), pp 883-899 (Oct 1976)

Key Words: Natural frequency, Damping characteristics, Parameter identification, Random excitation, Least squares method

A two-stage least-squares parameter estimation procedure using covariance function data is developed for the estimation of the natural frequency and damping parameters of randomly excited structural systems. The estimation procedure is statistically and computationally efficient and yields a measure of the statistical reliability of the structural parameter estimates. Examples of the estimation of the natural frequency and damping computed by forced vibration, correlation analysis, and two-stage least-squares methods are examined.

77-658

Estimating the Dynamic Properties of Mechanical Structures, Based on the Asymmetric Duffing Model

M. Kulisiewicz

Bull. Acad. Polon. Sci., Ser. Sci. Tech., 24 (7-8), pp 357-364 (1976) 4 figs, 8 refs

Key Words: Parameter identification

An identification method is presented for dynamic properties of structures, with a nonlinear asymmetric, Duffing-type model applied. As the method is active, it involves implementation of a properly selected periodic excitation for a model under investigation, which results in the desired state of a system. For such a state, proper resonance conditions have been derived which made it possible to create an algorithm based on the resonance criterion, which is of essential significance when estimating the structural life.

CRITERIA, STANDARDS, AND SPECIFICATIONS

77-659

Technical Review of Federal Aviation Regulations. Part 36. Noise Standards: Aircraft Certification

W.J. Galloway and D.E. Bishop

Bolt Beranek and Newman, Inc., Cambridge, MA

Rept. No. BBN-2943, 93 pp (Mar 1976)

PB-257 717/9GA

Sponsored by the Environ. Protection Agency, Arlington, VA, Off. of Noise Abatement & Control

Key Words: Aircraft noise, Regulations

This regulation and its first three amendments apply to noise standards for turbine powered subsonic aircraft regardless of category, and subsonic transport category aircraft, regardless of means of power. This report provides technical comment and analyses to support the EPA review of FAR 36 and its Appendices A, B, and C.

77-660

Analysis of the Public Health and Welfare Effects of EPA Proposed Aircraft Noise Regulations

W.J. Galloway

Bolt Beranek and Newman, Inc., Cambridge, MA,

Rept. No. BBN-3171, 40 pp (Mar 1976)

PB-257 716/1GA

Sponsored by the Environ. Protection Agency, Arlington, VA, Off. of Noise Abatement & Control

Key Words: Aircraft noise, Regulations

This report utilizes the concept of fractional impact analysis to assess several of the proposed regulations. In this concept the number of decibels that a noise exposure exceeds the identified levels specified in the EPA Levels report determines a fractional impact index.

77-661

Putting a Value on Noise -- The Development of an Index Which is Fair to Both Airport Operators and the Public

E.J. Richards

Institute of Sound and Vibration Research, Univ. of Southampton, Southampton S09 5NH, England, J. Sound Vib., 49 (1), pp 53-73 (Nov 8, 1976) 13 figs, 17 refs

Key Words: Airports, Noise generation, Regulations

A national, or regional, noise control agency having its own secretariat and speaking as an instrument of the community as a whole is suggested. Also, a Noise Burden Factor is proposed, to provide an applicable quantitative rating of the noise nuisance (dis-amenity) of any airport in respect to its socio-economic benefits (amenity). This factor is defined in terms of the number of man-days of serious noise nuisance per airport passenger.

77-662

A Perspective Overview of SAE Standards Activities for Sound Levels of Aircraft and Automotive Vehicles

R.K. Hillquist

P. O. Box 113, Milford, MI 48042, Noise Control Engr., 7 (1), pp 10-15 (July/Aug 1976) 13 refs

Key Words: Aircraft noise, Motor vehicle noise, Standards

From a simple beginning over fifty years ago, SAE activities in sound measurement and standardization have evolved into a broadly based effort affecting most engine-powered or self-propelled equipment types. These technical activities are regulated by Society rules and monitored by parent bodies to assure valid and nondiscriminatory test methods. The underlying philosophies of these methods are in keeping with the needs of the ultimate user, both industrial and governmental, and they are dynamic to meet changing requirements. Recognition of national and international efforts has resulted in greater SAE participation in these areas.

SURVEYS

77-663

Maneuvering Aircraft: Noise Pollution and Control (A Bibliography with Abstracts)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 229 pp (Sept 1976) (Supersedes NTIS/PS-75/762, and NTIS/PS-75/060)
NTIS/PS-76/0733/6GA

Key Words: Aircraft noise, Noise reduction, Bibliographies

Methods for alleviating noise created by maneuvering aircraft are cited. Flyby, turning flight, takeoffs, and landings are the maneuvers investigated.

77-664

Earthquake Engineering: Buildings, Bridges, Dams, and Related Structures. Volume 2. 1974-Aug 1976 (A Bibliography with Abstracts)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 245 pp (Oct 1976) (Supersedes NTIS/PS-75/633, and COM-74-11141)
NTIS/PS-76/0772/4GA

Key Words: Seismic design, Buildings, Bridges, Dams, Bibliographies

Seismic phenomena relative to buildings, bridges, dams, and other structures are investigated. Damage assessment is made and design inadequacies are revealed. Suggestions for structural improvements for dynamic response are presented. Abstracts on site selection and earthquake-proofing for atomic power plants are included.

TUTORIAL

77-665

Quieting: A Practical Guide to Noise Control

R.D. Berendt, E.L.R. Corliss, and M.S. Ojalvo

Inst. for Basic Standards, National Bureau of Standards, Washington, D.C.
PB-258 046/2GA

Key Words: Noise reduction

The guide offers practical solutions for ordinary noise problems that a person is likely to meet. Discussions are made of sound generation, transmission to the listener, and impacts on hearing and well being. Recommendations are made for controlling noise both at source and in travel, and for protecting the listener. Warning signs are noted that determine whether one is being subjected to hazardous prolonged noise. Remedies are suggested for home, work, and school, for traveling, and in the community. An index is given for noise sources.

MODE SYNTHESIS AND ANALYSIS

(Also see Nos. 701, 724, 805, 806)

77-666

Modal Surveys of Weakly Coupled Systems

A.L. Klosterman

Structural Dynamics Research Corp., SAE Paper No. 760876, 12 pp, 25 figs, 2 refs

Key Words: Modal analysis, Coupled systems

It is shown in this paper that in certain types of physical systems, mode shapes are so highly sensitive to small changes in the physical properties of the system that close agreement between computed and experimentally measured mode shapes cannot be expected. It will be shown, for example, that in certain situations stiffness changes in the order of five percent give rise to changes in coupled mode shapes of the order of fifty percent.

77-667

An Iterative, Self-Organizing Method for the Determination of Structural Dynamic Characteristics

M. Feix

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1975-1 (ESA-TT-232) Dec 1975, pp 36-60 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, No. 1975-1, Jan-Feb 1975, pp 21-33, N76-31180)
N76-31183

Key Words: Modal analysis

A method for determining the modal characteristics of a structure from harmonic vibration tests at several frequencies is presented. It was assumed that in regard to resonance only a small number of modes give an appreciable answer and that the structure behaves like a system with only a few degrees of freedom. Used are either applied forces or mass overloads. The method appears as iterative: starting from a force (or a mass) arbitrarily applied, progress is made by steps, each step providing indications for the execution of the next, while a test shows if the number of degrees of freedom to be considered is reached. Neither the number of degrees of freedom nor the location of excitation (or mass) points are fixed a priori, except for the first one. The practical interest of the method is illustrated by application to a theoretical and an actual structure.

77-668

Modal Analysis with the DMS/TSA System

D.J. Durham and R.H. Russell

Zonic Technical Labs., Inc., SAE Paper No. 760877, 32 pp, 33 figs, 4 refs

Key Words: Modal analysis, Computer programs, Fast Fourier transform

Digital signal processing systems using the FFT (Fast Fourier Transform) have increased the efficiency and power of modal analysis in solving dynamics problems. The generation of animated deformation plots by the FFT provides a very useful tool for studying complex structures vibrating at resonant frequencies. Digital processing systems have automated the procedure for developing these plots and have allowed the extraction of multiple plots from a single set of data. This paper outlines the development of animated deformation plots from experimental frequency response information. Emphasis is placed on the use of a local and time-shared analysis system (the DMS/TSA) for cost effective analysis procedures.

77-669

Calculated Restitution of Structural Natural Modes from Non-Appropriated Excitations

X.T. Nguyen

European Space Agency, Paris, France, Rept. No. ESA-TT-295; ONERA-NT-1975-9, 58 pp (May 1976) (Engl. transl. from "Restitution par Calcul des Modes Propres a Partir d'Excitations Non Appropriees", ONERA, Paris, Report ONERA-NT-1975-9)
N76-31590

Key Words: Fundamental modes, Modal analysis

After a review of the theoretical bases and experimental methods used for the ground vibration test, the fundamental problem of determining the modal data is discussed. The results calculated in this manner are perfectly comparable to those obtained with a test performed with conventional isolation processes.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 668, 848)

77-670

Eigenvalue Extraction in NASTRAN by the Tridiagonal Reduction (FEER) Method: Real Eigenvalue Analysis. Final Report

M. Newman and P.F. Flanagan

Analytical Mechanics Associates, Inc., Jericho, NY, Rept. No. NASA-CR-2731, 65 pp (Aug 1976)

N76-31933

Key Words: Eigenvalue problems, Computer programs

The development of the tridiagonal reduction method and its implementation in NASTRAN are described for real eigenvalue analysis as typified by structural vibration and buckling problems. This method is an automatic matrix reduction scheme whereby the eigensolutions in the neighborhood of a specified point in the eigenspectrum can be accurately extracted from a tridiagonal eigenvalue problem whose order is much lower than that of the full problem. The process is effected without artibrary lumping of masses or other physical quantities at selected node points and thus avoids one of the basic weaknesses of other techniques.

77-671

Aircraft Configuration Noise Reduction. Volume II. Computer Program User's Guide and Other Appendices

D.G. Dunn, D.J. Cecil, L.M. Butzel, J.M Campbell and H.Y. Lu

Boeing Commerical Airplane Co., Seattle, WA., Rept. No. D6-42849-2, FAA/RD-76/76-2, 140 pp (June 1976) (see also Vol. 3, AD-A030 657)

AD-A030 656/3GA

Key Words: Computer programs, Aircraft noise, Noise reduction, Configuration effects

This report (volume 2) contains: The user's guide for the computer software of the aircraft configuration noise reduction study: A preliminary test plan for assessing forward velocity effects on wing and fuselage shielding; and Various curves, derivations, and background theory in support of material presented in volume 1.

77-672

Aircraft Configuration Noise Reduction. Volume III. Computer Program Source Listing

D.G. Dunn and D.J. Cecil

Boeing Commerical Airplane Co., Seattle, WA., Rept. No. D6-42849-3, FAA/RD-76/76-3, 298 pp (June 1976) (See also vol. 1, AD-A030 655)

AD-A030 657/1GA

Key Words: Computer programs, Aircraft noise, Noise reduction, Configuration effects

This report (volume 3) contains the source code listing of the computer programs for evaluating aircraft configuration noise reduction as defined in the engineering document, volume 1. The User's Guide for the programs is contained in appendix A of Volume 2. The material presented herein is reference data for use in conjunction with the material presented in volumes 1 and 2.

77-673

NOVA 2 -- A Digital Computer Program for Analyzing Nuclear Overpressure Effects on Aircraft. Part 1. Theory

W.N. Lee and L.J. Mente

Kaman Avidyne, Burlington, MA., Rept. No. KA-TR-128-Pt-1, AFWL-TR-75-262-Pt-1, 212 pp (Aug 1976) (see also AD-A029 389)

AD-A029 388/6GA

Key Words: Computer programs, Nuclear explosion effects, Aircraft, Structural members

NOVA-2 (Nuclear Overpressure Vulnerability Analysis, Version 2) is an updated version of NOVA, a FORTRAN-4 digital computer program for calculating the response of individual structural elements of aircraft, such as stringers, frames and panels, exposed to the transient pressure loading associated with the blast wave from a nuclear explosion. The updated version extends the capability of NOVA to analyze rib elements, frames with variable cross section, and offers a choice of clamped, simply supported or free edge boundary conditions. For inelastic structural response, a much improved elastic-plastic model for material behavior is provided. Also added to NOVA is the REFRA near-ground reflections model for blast waves. The program still provides the overall capability to analyze multilayered beam and panel elements exposed to a steady-state subsonic or supersonic aerodynamic preload, followed by a dynamic blast wave. A critical slant range is automatically determined in an iteration where damage criteria (specified on a probabilistic basis) are compared with the structural response.

77-674

NOVA 2 -- A Digital Computer Program for Analyzing Nuclear Overpressure Effects on Aircraft. Part 2. Computer Program

W.N. Lee and L.J. Mente

Kaman Avidyne, Burlington, MA., Rept. No. KA-TR-128-Pt-2, AFWL-TR-75-262-Pt-2, 155 pp (Aug 1976) (see also AD-A029 338)

AD-A029 389/4GA

Key Words: Aircraft, Panels, Frames, Nuclear explosion effects, Computer programs

NOVA-2 (Nuclear Overpressure Vulnerability Analysis, Version 2) is an updated version of NOVA, a FORTRAN-4 digital computer program for calculating the response of individual structural elements of aircraft, such as stringers, frames and panels, exposed to the transient pressure loading associated with the blast wave from a nuclear explosion. The updated version extends the capability of NOVA to analyze rib elements, frames with variable cross section, and offers a choice of clamped, simply supported or free edge boundary conditions.

77-675

DYNALIST II: A Computer Program for Stability and Dynamic Response Analysis of Rail Vehicle Systems. Volume II. User's Manual

A. Bronowicki and T.K. Hasselman

J.H. Wiggins Co., Redondo Beach, CA., Rept. No. DOT-TSC-FRA-74-14.II, FRA/ORD-75-22.II, 97 pp (Feb 1975) (see also PB-256 046)

PB-257 733/6GA

Key Words: Computer programs, Interaction: rail-wheel, Railroad cars

A methodology and a computer program, DYNALIST 2, have been developed for computing the response of rail vehicle systems to sinusoidal or stationary random rail irregularities. The computer program represents an extension of the earlier DYNALIST program. A modal synthesis procedure is used which permits the modeling of subsystems or components by partial modal representation using complex eigenvectors. Both vertical and lateral motion are handled by the program which allows up to twenty-five component and fifty system degrees of freedom.

77-676

DYNALIST II. A Computer Program for Stability and Dynamic Response Analysis of Rail Vehicle Systems. Volume III. Technical Report Addendum

A. Bronowicki and T.K. Hasselman

J.H. Wiggins Co., Redondo Beach, CA., Rept. No. DOT-TSC-FRA-74-14-111, FRA/ORD-75/22.111, 74 pp (July 1976) (also see PB-256 046 and PB-258 194)

PB-258 193/2GA

Key Words: Computer programs, Dynamic response, Railroad cars, Suspension systems (vehicles)

Several new capabilities have been added to the DYNALIST II computer program. These include: a component matrix generator that operates as a 3-D finite element modeling program where elements consist of rigid bodies, flexural bodies, wheelsets, suspension elements and point masses assembled on a nodal skeleton; a periodic and transient time-history response capability; a component update capability for parametric studies; an orthogonality check on component and system complex eigenvectors; an option for improving low-frequency convergence under modal trunction; a more general sine-amplitude forcing function capability; automatic phase lag generation; user-controlled scaling options on all response plots; and a number of additional minor improvements. A Technical Report Addendum and a completely revised User's Manual document these changes to the previous version of DYNALIST II.

77-677

DYNALIST II. A Computer Program for Stability and Dynamic Response Analysis of Rail Vehicle Systems. Volume IV. Revised User's Manual

A. Bronowicki and T.K. Hasselman

J.H. Wiggins Co., Redondo Beach, CA., Rept. No. DOT-TSC-FRA-74/14-IV, FRA/ORD-75/22.IV, 156 pp (July 1976) (see also PB-258 193)

PB-258 194/0GA

Key Words: Computer programs, Dynamic response, Railroad cars

The Revised User's Manual reflects current modifications in output format which have been written into the DYNALIST II program.

77-678
PFVIBAT – A Computer Program for Plane Frame Vibration Analysis by an Exact Method
B.A. Akesson
Div. of Solid Mechanics, Chalmers Univ. of Tech., Gothenburg, Sweden, Intl. J. Numer. Methods Engr., 10 (6), pp 1221-1231 (1976) 8 figs, 33 refs

Key Words: Computer programs, Frames, Beams, Transient vibrations

The described program PFVIBAT uses the exact displacement method to perform free and forced vibration analysis entirely within the differential equation theory of beams thus avoiding assumed modes and lumped masses. The frame may contain rigid bodies. Clamped, hinged, guided and rolling connections are allowed for. Consideration of rotatory inertia, shear deformation and second-order bending moments and shear forces as caused by static axial load is optional. Eigenfrequencies and modal masses are calculated with an accuracy that may be specified. Displacement and moment modes are plotted. Transient vibrations are studied.

77-679
On a Numerical Solution of the Supersonic Panel Flutter Eigenproblem
K.K. Gupta
Jet Propulsion Lab., California Inst. of Technology, Pasadena, CA., Intl. J. Numer. Methods Engr., 10 (3), pp 637-645 (1976) 11 refs

Key Words: Flutter, Panels, Computer programs, Finite element technique

An automated digital computer procedure is presented in this paper which enables efficient solution of the eigenvalue problem associated with the supersonic panel flutter phenomena. The step-by-step incremental solution procedure is based on an inverse iteration technique which effectively utilizes solution results from the previous step in determining such results during the current solution step. Also, the computations are limited to the determination of a few specific roots only, which are expected to contain the flutter mode, and this is achieved at each step without having to compute any other root. The structural discretization achieved by the finite element method yields highly banded stiffness, mass, and aerodynamic matrices; the aerodynamic matrix evaluated by the linearized piston theory is real but unsymmetric in nature. Numerical results are presented for a two-dimensional panel flutter problem.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 659, 660, 661, 690, 691, 694, 695, 708, 717, 719, 722, 734, 759, 782, 784, 787, 788, 807, 817, 819, 835, 840, 846)

77-680
Wave Propagation in a Nonlinear Laminated Material: A Derivation of Geometrical Acoustics
M.P. Mortell and B.R. Seymour
Dept. of Mathematical Physics, University College, Cork, Ireland, Quart. J. Mech. Appl. Math., 29 (4), pp 457-466 (Nov 1976) 5 refs

Key Words: Sound waves, Wave propagation, Laminates

The problem of describing the propagation of a wave through a nonlinear elastic laminated composite is considered, under the restriction that the mismatch of successive impedances is small. A theory neglecting all reflections is derived and is shown to limit to the first term in a nonlinear geometrical-acoustics expansion for a nonuniform continuous medium. When the composite has a periodic structure the limiting medium is a nonlinear viscoelastic material.

77-681
Effect of Nonlinearity on Noise Propagation
F.M. Pestorius, S.W. Williams and D.T. Blackstock
Applied Research Labs., Texas Univ. at Austin, Austin, TX, Rept. No. AFOSR-TR-76-0997, 15 pp (1974)
AD-A029 927/1GA

Key Words: Sound transmission

A previous study of plane waves of noise has been followed up by extending the analysis to the problem of noise propagation in open media. Plane wave analysis was extended to cover spherically and cylindrically spreading waves. Scaling rules concerning the effects of frequency and amplitude were determined. Distortion computations were made using a particular example of actual jet noise, noise of not very high intensity from the British-French Concorde.

77-682

Far-Field, Finite-Amplitude Radiation from Directive Sources

J.C. Lockwood, T.G. Muir and D.T. Blackstock
Applied Research Labs., Texas Univ. at Austin, Austin, TX, Rept. No. AFOSR-TR-76-0980, 5 pp (1971)
AD-A029 929/7GA

Key Words: Elastic waves, Harmonic analysis

The theory of far-field radiation from intense spherical and cylindrical sources has been extended to include effects of directivity. Examples include the dipole, quadrupole, and baffled piston. Experimental measurements of the directivity of harmonics when the source is a piston are discussed to show the extent of validity of the theory.

77-683

Scattering of Sound by a Lifting Boundary

D.S. Jones
Dept. of Mathematics, The University, Dundee, DD1 4HN, England, Quart. J. Mech. Appl. Math., 29 (4), pp 429-455 (Nov 1976) 2 refs

Key Words: Acoustic scattering, Cylinders

A rigid cylinder is placed in a fluid with steady velocity perpendicular to its generators and with a given circulation. The flow is irradiated by time-harmonic sound waves from a line source parallel to the cylinder. The far field is obtained when the Mach number of the background flow is small and the frequency of excitation is low.

77-684

A Normal Mode Model for Estimating Low-Frequency Acoustic Transmission Loss in the Deep Ocean

K.E. Evans
Naval Postgraduate School, Monterey, CA., 178 pp (Sept 1975)
AD-A030 078/0GA

Key Words: Underwater sound, Sound transmission loss, Normal modes, Computer programs

This work describes a computer model (QMODE) which uses the normal mode method for the estimation of low-frequency long-range acoustic transmission loss in the deep ocean. Wentzel-Kramer-Brillouin (WKB) solutions for the phase speeds (eigenvalues) and modes (eigenfunctions). The WKB solutions are extended to consider the effects of the surface and bottom boundaries.

77-685

Virtual Modes and the Surface Boundary Condition in Underwater Acoustics

C.T. Tindle, A.P. Stamp and K.M. Guthrie
Dept. of Physics, Univ. of Auckland, Auckland, New Zealand, J. Sound Vib., 49 (2), pp 231-240 (Nov 22, 1976) 3 figs, 12 refs

Key Words: Underwater sound, Sound waves

An explicit expression for the contribution of continuous normal modes to the acoustic pressure field in shallow water is derived under the assumption of constant sound speed in the bottom. An approximate evaluation of the resulting integral leads to a summation over "virtual" modes. These virtual modes are similar to the trapped modes except that their amplitudes decay with range. The validity of the "pressure release" boundary condition at the surface is investigated. This approximate boundary condition is justified by allowing for energy leakage into the air and examining the virtual mode contribution to the normal mode expression.

RANDOM

(See Nos. 671, 672)

SEISMIC

(Also see Nos. 664, 701, 702, 703, 704, 705, 706, 707, 765, 768, 796, 797, 798, 799, 812, 821, 822, 823, 824, 825, 826, 827, 828, 829)

77-686

Random Vibration Analysis of Inelastic Multi-Degree-of-Freedom Systems Subjected to Earthquake Ground Motions

G. Gazetas
Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA., Rept. No. R76-39, 322 pp (Aug 1976)
PB-258 311/0GA

Key Words: Random vibration, Multidegree of freedom systems, Seismic response, Multistory buildings

A random vibration method is presented to predict the probability distribution of the maximum inelastic response of deterministic, multi-degree-of-freedom, elastoplastic systems subjected to earthquake ground motions described by a single power spectral density function and a strong motion duration. Extensive simulation studies are used as a guide for the development of the theory, as they yield a better understanding of the elastoplastic dynamic behavior of multistory systems. The theory is evaluated by comparing its response predictions with statistics from multiple time-integration analyses. Various two- and four-degree-of-freedom structures and motions with different frequency content and motion duration are used for this evaluation.

77-687

Identification of Structures Through Records Obtained During Strong Earthquake Ground Motion

F.E. Udwadia and P.C. Shah

Univ. of Southern California, Los Angeles, CA., J. Engr. Indus., Trans. ASME, 98 (4), pp 1347-1362 (Nov 1976) 12 figs, 13 refs

Key Words: Beams, Buildings, Seismic response spectra

This paper is concerned with the problem of estimating a space dependent coefficient in a forced linear hyperbolic differential equation from the knowledge of the solution at one or more isolated points. The continuous model of a structural system by a shear beam is used to study the utility of earthquake records in determining structural models.

SHOCK

(Also see Nos. 671, 672, 699, 735, 785, 834, 847)

77-688

Anthropometric Test Dummy, Model 825-50, Design, Development and Performance

J.L. Roshala and L.E. Popp

Sierra Engrg. Co., Sierra Madre, CA., Rept. No. TR-825-900, DOT-HS-801 917, 245 pp (Aug 1976) PB-257 179/2GA

Key Words: Collision research (automotive), Anthropomorphic dummies

This report covers the development, manufacture, testing, and evaluation of two (2) 50th percentile male anthropomorphic test dummies. The objective was to develop a test dummy which could be used for compliance tests with appropriate Federal Motor Vehicle Safety Standards in the evaluation of protection systems for vehicle occupants during real and simulated impact conditions. Corresponding dummy test data which could be made available to any source interested in manufacturing, checking, comparing with other dummy configurations was studied.

PHENOMENOLOGY

COMPOSITE

(Also see Nos. 680, 766)

77-689

Small Vibrations of a Fibre-Reinforced Composite

N. Scott and M. Hayes

Dept. of Mathematics, Univ. of Dundee, Dundee, Quart. J. Mech. Appl. Math., 29 (4), pp 457-486 (Nov 1976) 8 refs

Key Words: Composite materials, Fiber composites, Vibration response

An idealized model of an elastic material subject to the internal constraints of inextensibility along a given fixed direction, and of incompressibility, is used to examine the propagation of small-time harmonic plane waves in a homogeneous isotropic composite which is subjected to a finite static pure homogeneous deformation. The theory for small deformations superimposed upon large is developed. The case when there is no initial deformation is considered. This theory includes as a special case the classical linear theory of wave propagation in an incompressible transversely-isotropic material which is inextensible in the direction of the axis of anisotropy.

77-690

A Model Theory for the Fibrous Absorber, Part 1: Regular Fibre Arrangements

F.P. Mechel

Universität des Saarlandes, Labor Akustik, Saarbrucken, Grunzweig + Hartmann und Glasfaser AG, Ludwigshafen, Acustica, 36 (2), pp 65-89 (Oct 1976) 22 figs, 13 refs (In German)

Key Words: Sound waves, Acoustic absorption, Fiber composites

The axial propagation of sound waves in a mode consisting of parallel fibres were calculated. The viscous forces and the thermal conduction were taken into account. This lead to viscous waves and to thermal waves besides the usual acoustic compressional wave. The potential function for the total field near a fibre was treated as the superposition of the radiated field from the fibre itself and of the scattered fields from all the other fibres. The explicit field equations for a regular square fibre arrangement was derived and the influence of the order of symmetry of the arrangement was discussed.

77-691

A Model Theory for the Fibrous Absorber. Part II: A Model Consisting of Elementary Cells and the Numerical Results

F.P. Mechel

Universitat des Saarlandes, Labor Akustik, Saarbrucken; Grunzweig + Hartmann Montage GmbH, Ludwigshafen/Rhein, Acustica, 36 (2), pp 53-64 (Oct 1976) 3 figs, 3 refs

(In German)

Key Words: Sound waves, Acoustic absorption, Fiber composites

The problem of sound propagation in a model absorber consisting of parallel fibres is formulated as a boundary value problem of elementary cells surrounding each fibre. Numerical solutions of the equations are presented and simple approximations for the characteristic propagation constant and for the characteristic wave impedance of the absorber are derived. Particle velocity profiles near the fibres are computed also. The results are compared to other absorber theories.

DAMPING

(Also see Nos. 653, 740, 770)

77-692

Solid Friction Damping of Mechanical Vibrations

P.R. Dahl

The Aerospace Corp., El Segundo, CA., AIAA J., 14 (12), pp 1675-1682 (Dec 1976) 11 figs, 8 refs

Key Words: Coulomb friction, Mathematical models

A theory of solid friction damping of mechanical vibrations is presented that is based on a solid friction mathematical model previously proposed by the author. A summary and improved description of the general analytic features of the solid friction model are given as necessary background for the theory. The Coulomb friction damped oscillator is analyzed to establish an approach to the treatment of a simple friction damped oscillator. The approach then is generalized to treat a more general model of friction where the author's model is used to describe friction force primarily as a function of displacement. The solid friction damped oscillator studied is a wire pendulum where solid friction enters via inelastic flexing of the wire at the support. Theoretical results are generalized to be applicable to other types of oscillators and other sources of solid friction. An expression for the decay rate of the oscillation amplitude envelope of an unforced oscillator is derived. The decay rate and an equivalent linear damping ratio are determined for several values of an exponent parameter in the solid friction model.

77-693

The Effect of Damping on the Vibration-Stability Relation of Linear Systems

D.E. Beskos

Dept. of Civil and Mineral Engrg., Univ. of Minnesota, Minneapolis, MN 55455, Mechanics Research Communications, 3 (5), pp 373-377 (1976) 1 fig, 6 refs

Key Words: Flexural vibration, Beams, Plates, Damping effects

The relation between flexural vibration and elastic stability for linear elastic systems without damping has been investigated in the past. In this paper the damping of the system is taken into account, and its influence on the previous results is studied. Two kinds of damped systems are considered: beams and plates with continuous mass distribution and a linear elastic discrete system of a finite number of degrees of freedom.

FLUID

(Also see Nos. 683, 684, 685, 769, 774, 776, 814, 816)

77-694

On the Velocity of a Rigid Sphere in a Sound Wave

S. Temkin and C.M. Leung

Dept. of Mechanical, Industrial and Aerospace Engrg., Rutgers Univ., New Brunswick, NJ 08903, J. Sound Vib., 49 (1), pp 75-92 (Nov 8, 1976) 6 figs, 22 refs

Key Words: Spheres, Fluid-induced excitation, Sound waves

A study is presented of the oscillatory motion of a rigid sphere that is induced by a plane, monochromatic sound wave traveling in a viscous, non-heat-conducting fluid of infinite extent. Results for the sphere's velocity amplitude and phase, relative to those of the fluid, are obtained for sound waves of arbitrary frequency. These reduce to those predicted by irrotational flow theory, and to those obtained from viscous, incompressible, unsteady flow theory.

77-695

In-Fluid Response of Complex Structures with Application to Orthotropic Spheres

J.J. Engblom and R.B. Nelson

Hughes Aircraft Co., Culver City, CA 90230, J. Sound Vib., 49 (1), pp 1-8 (Nov 8, 1976) 3 figs, 12 refs

Key Words: Spheres, Fluid-induced excitation, Finite element technique

A method is presented for determining the response of a closed structure, immersed in an infinite acoustic medium, undergoing harmonic vibratory motion. The mathematical representation of the structure is based on a finite element approach so that arbitrarily shaped surfaces with or without internal structures may be studied. Applied and fluid-structure interaction forces are related to response quantities through a velocity mobility matrix form, obtained via an in vacuo eigensolution. A supplemental acoustic relationship in velocity impedance matrix form is used to quantify the effects of the fluid medium. This relation, based on a discretization of the Helmholtz integral equations, assures continuity of the acoustic variables at the fluid-structure boundary. Both structure and fluid-structure relationships are combined to yield a structural-acoustic velocity mobility matrix form suitable for digital computer solution. The formulation is utilized to investigate the response of solid isotropic, hollow isotropic and laminated orthotropic spheres.

77-696

Predicting Flow Induced Vibration in U-Bend Regions of Heat Exchangers: An Engineering Solution

K.P. Singh

Joseph Oat Corp., 2500 Broadway, Camden, NJ, J. Franklin Inst., 302 (2), pp 195-205 (Aug 1976) 5 figs, 14 refs

Key Words: Heat exchangers, Fluid-induced excitation

A method to obtain an engineering solution to determine the velocity profile in the U-bend region is proposed in this paper which may be utilized in conjunction with the available correlations to reliably predict the possibility of vibration. Determination of the flow profile may be further utilized to improve the estimates of shellside heat transfer coefficients.

77-697

Understanding Flow-Induced Vibrations. Part 1: Basic Concepts; Fluid Forcing Functions

M.W. Wambsganss

Argonne National Lab., Argonne, IL, S/V, Sound Vib., 10 (11), pp 18-23 (Nov 1976) 8 figs, 15 refs

Key Words: Fluid-induced excitation

This article is written in two parts. The basic requirements of a flow-induced vibration analysis or test, including adequate descriptions of the fluid environment and pertinent structures, are considered in Part I. The major portion of this part is devoted to discussion of the four different types of fluid excitation forces.

77-698

Mathematical Model of the Vibration Induced by Vortex Shedding

E. Szechenyi

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1975-5 (ESA-TT-298) May 1976, pp 138-168 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel (Paris), No. 1975-5, Sept-Oct 1975, pp 301-312, N76-32103) N76-32109

Key Words: Mathematical models, Vortex shedding, Cylinders

A mathematical model to allow for the lift forces a blunt cylindrical body experinece under the action of a flow perpendicular to its axis was established. The response of the structure to be calculated is accounted for. The model is based on simple physical concepts. It also makes use of the results of experiments carried out at high Reynolds numbers. The agreement between calculation and experiment is satisfactory for a test performed in a wind-tunnel on a flexible cylinder.

SOIL

77-699

A Method for Designing Deep Underground Structures Subjected to Dynamic Loads

J.L. Drake and J.R. Britt

Army Engineer Waterways Experiment Station, Vicksburg, MS., Rept. No. WES-TR-N-76-9, 31 pp (Sept 1976)

AD-A030 601/9GA

Key Words: Underground structures, Hardened structures, Nuclear explosion effects

This report describes solutions to a class of dynamic elastoplastic problems that model some of the salient features of the response of hardened underground facilities in rock. The theoretical model consisted of multilayered concentric cylinders of elastoplastic materials with time-dependent loads applied to the exterior boundary.

77-700

Finite Element, Similitude and Soil Structure Interaction Study of Buried Cylinders Under Dynamic Loading

C.E. Pace
Ph.D. Thesis, Univ. of Arkansas, 313 pp (1976)
UM 76-26, 388

Key Words: Interaction: soil-structure, Underground structures, Cylinders, Shock wave propagations, Computer programs, Missile launchers

A dynamic shock wave test of 550 psi maximum pressure was performed on a prototype (6 ft diameter by 7-½ ft high) and a ¼-scale model, both of axisymmetric reinforced concrete construction. The objectives of this test were to: verify similitude theory of response between prototype and model; make computations of prototype and free field response by using a finite element computer program and compare the finite element calculations with experimental data and; to determine the interaction forces on the model and prototype.

77-701

Modal Analysis for Building-Soil Interaction

J. Bielak
Inst. de Ingenieria, Universidad Nacional Autonoma de Mexico, Mexico, D.F., Mexico, ASCE J. Engr. Mech. Div., 102 (EM5), pp 771-786 (Oct 1976)

Key Words: Interaction: soil structure, Earthquake response, Modal damping, Modal analysis

An approximate method of modal analysis is presented for the earthquake response of linear building-foundation systems. To estimate the accuracy of the suggested method, both analytical and numerical studies are performed. Several examples are included to illustrate the effect of hysteretic soil damping on the system response.

77-702

A Substructure Method for Earthquake Analysis of Structure-Soil Interaction

J.A. Gutierrez and A.K. Chopra
Earthquake Engrg. Res. Center, Calfiornia Univ., Berkeley, CA., Rept. No. EERC-76-9, 153 pp (Apr 1976)
PB-257 783/1GA

Key Words: Interaction: soil-structure, Seismic response, Finite element technique, Computer programs

A general substructure method for analysis of response of structures to earthquake ground motion including the effects of structure-soil interaction is presented. Flexibility of the structural base, spatial variations in the free field ground motion, structural embedment and interaction between two or more structures are among factors included in the analysis.

77-703

Soil-Structure Interaction Parameters from Finite Element Analysis

C.J. Costantino, C.A. Miller and L.A. Lufrano
Dept. of Civil Engrg., The City College of the City University of New York, New York, NY 10031, Nucl. Engr. Des., 38 (2), pp 289-302 (Aug 1976)
30 figs, 4 refs

Key Words: Interaction: soil-structure, Finite element technique, Seismic response

A series of two-dimensional finite element computer runs were made to compute the frequency dependent soil-structure interaction coefficients. Variations in the element size, mesh dimensions, boundary conditions, and soil hysteretic damping ratio to determine their influence on the computed interaction coefficients were made.

77-704

Special Topics on Soil-Structure Interaction

J.R. Hall, Jr. and J.F. Kessenpfennig
E. D'Appolonia Consulting Engineers, Inc., B-1180 Brussels, Belgium, Nucl. Engr. Des., 38 (2), pp 273-287 (Aug 1976) 15 figs, 45 refs

Key Words: Interaction: soil-structure, Finite element technique, Lumped parameter method, Seismic response, Nuclear power plants

A summary of the advantages and limitations of lumped parameter and finite element technique in the design of nuclear power plants are presented including the state of the art in the determination of soil stiffness and material damping characteristics. Furthermore, the paper illustrates one type of analysis technique which uses a hybrid approach of both finite element results and lumped parameter solutions. Details of the lumped parameter approach for embedded foundations and an illustration with numerical examples are provided. Recommendations are then presented on a procedure for soil-structure interaction of deeply embedded foundations.

77-705

Soil-Structure Interaction - An Engineering Solution

A.H. Hadjian

Bechtel Power Corp., Los Angeles Power Div., Norwalk, CA 90650, Nucl. Engr. Des., 38 (2), pp 267-272 (Aug 1976) 4 figs, 19 refs

Key Words: Interaction: soil-structure, Seismic response, Impedance, Finite element technique, Nuclear power plants

The two methods of analysis for soil-structure interaction, the impedance and the finite element methods, are reviewed with regard to their present capabilities to address the significant factors of the problem. The objective of the paper is to evaluate if an adequate engineering solution to the problem is provided by either approach. Questions related to the reduction of seismic motions with depth, scattering of incident waves, the three-dimensionality of the real problem, soil damping, strain dependency of soil properties and the uncertainties associated with all of the above are discussed in sufficient detail.

77-706

Effect on Non-Linear Soil-Structure Interaction Due to Base Slab Uplift on the Seismic Response of a High-Temperature Gas-Cooled Reactor (HTGR)

R.P. Kennedy, S.A. Short, D.A. Wesley and T.H. Lee

Holmes & Narver, Inc., Anaheim, CA 92801, Nucl. Engr. Des., 38 (2), pp 323-355 (Aug 1976) 24 figs, 6 refs

Key Words: Interaction: soil-structure, Seismic response, Nuclear power plants

The primary purpose of this paper is to evaluate the importance of the nonlinear soil-structure interaction effects resulting from substantial base slab uplift occurring during a seismic excitation. The structure considered for this investigation consisted of the containment building and pre-stressed concrete reactor vessel (PCRV) for a typical HTGR plant. A simplified dynamic mathematical model was utilized consisting of a conventional lumped mass structure with soil-structure interaction accounted for by translational and rotational springs whose properties are determined by elastic half space theory. Three different site soil conditions (a rock site, a moderately stiff soil, and a soft soil site) and two levels of horizontal ground motion (0.3 and 0.5 g earthquakes) were considered.

77-707

Soil-Structure Interaction with Separation of Base Mat from Soil (Lifting-Off)

J.P. Wolf

Elektrowatt Engrg. Services, Ltd., CH-8022 Zurich, Switzerland, Nucl. Engr. Des., 38 (2), pp 357-384 (Aug 1976) 22 figs, 22 refs

Key Words: Interaction: soil-structure, Nuclear reactors, Plates, Seismic response

In reactor buildings having a separate base mat and a shield-building (outer concrete shell) of large mass, large overturning moments are developed for severe earthquake loading. The standard linear elastic half-space theory is used in the soil-structure interaction model and results are discussed.

77-708

Probabilistic Frequency Variations of Structure-Soil Systems

C.W. Hamilton and A.H. Hadjian

Univ. of Southern California, Los Angeles, CA 90007, Nucl. Engr. Des., 38 (2), pp 303-322 (Aug 1976) 13 figs, 11 refs

Key Words: Interaction: soil-structure, Probability theory, Seismic response

This paper studies the variations of material properties as they apply to structure-soil system frequencies during earthquakes. The emphasis in this paper is both on developing the methodology and on the results obtained. It covers both the fixed-base structure and the effects of soil-structure interaction. Empirical data on concrete properties were obtained from previously published results.

77-709

Propagation of Ground Vibration: A Review

T.G. Gutowski and C.L. Dym

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 49 (2), pp 179-193 (Nov 22, 1976) 11 figs, 17 refs

Key Words: Ground vibration, Traffic induced vibrations, Reviews

A review of the current state of the art of ground vibration propagation is presented herein. First the theoretical models of vibration attenuation are reviewed and then measurement techniques are discussed. Finally, measurement and theory are combined into predictive models, whose validity is discussed.

77-710
Effect of Time Dependent Compressibility on Non-Linear Viscoelastic Wave Propagation

D. Courtine, F.A. Cozzarelli and R.P. Shaw

Dept. of Applied Science & Mathematics, Jamestown Community College, Jamestown, NY., Intl. J. Non-linear Mech., 11 (6), pp 365-383 (1976) 17 figs, 31 refs

Sponsored by ONR

Key Words: Viscoelastic media, Wave propagation, Constitutive equations

The work presented consists essentially of two parts: the first deals with the development of a non-linear constitutive equation for a three-dimensional viscoelastic material with instantaneous and time dependent compressibility; the second deals with the solution of some specific wave propagation problems for three simple three-dimensional geometries.

77-711
A Wave-Front Method for Determining the Dynamic Properties of High Damping Materials

R.H. Blanc and F.P. Champomier

Laboratoire de Mecanique et d'Acoustique, C.N.R.S., Marseille, France, J. Sound Vib., 49 (1), pp 37-44 (Nov 8, 1976) 2 figs, 9 refs

Key Words: Viscoelastic damping

The dynamic properties of a viscoelastic medium are deduced from the development of a stress pulse wave-front during propagation through a bar of the material. An appropriate experimental set-up is described, whereby the wave-front can be recorded with respect to time after travelling through two distances along the bar. An example is provided for which the velocity of propagation and the damping are calculated. In the discussion, a corrective factor is established for eliminating the error due to modelling the wave.

EXPERIMENTATION

DIAGNOSTICS

77-712
Techniques of Vibration Analysis Applied to Gas Turbines

R. Chisholm

Imperial Oil Limited, Calgary, Alberta, Canada, Gas Turbine International, 17 (6), pp 16-22 (Nov-Dec 1976) 12 figs, 6 refs

Key Words: Gas turbines, Diagnostic instrumentation, Vibration analyzers, Diagnostic techniques

This paper discusses the results of a two-year program of monitoring the vibration of 30 Solar Saturn and Centaur gas turbines using a real time vibration analyzer. The advantages of a real time analyzer over earlier types of analyzers in troubleshooting units with excessive vibration are discussed. The use of vibration bar charts to evaluate the mechanical condition of a unit is illustrated. An example of a vibration spectrum or signature analysis is given for each section of the turbine-compressor package. Techniques of determining the source of vibration are also outlined. Forms of analysis to troubleshoot unique causes of high vibration, other than using vibration spectrums, are illustrated.

77-713
Design and Evaluation of Ball and Roller Bearing Analyzers

L.W. Winn

Mechanical Technology, Inc., Latham, NY., Rept. No. MTI-76TR27, AMMRC-CTR-76-27, 34 pp (Aug 1976)

AD-A030 536/7GA

Key Words: Ball bearings, Roller bearings, Diagnostic instrumentation

This report presents a description of the design and evaluation procedure employed in the construction of a ball bearing and roller bearing analyzer. The analyzers' capability to differentiate between acceptable and rejectable bearings has been demonstrated on a pilot sample. The results obtained on the analyzer were in excellent agreement with results of manual bearing inspection.

77-714

Listening for the Sounds

R.C. Beercheck

Mach. Des., 48 (27), pp 82-92 (Nov 25, 1976)

Key Words: Diagnostic instrumentation, Bearings

New instruments which monitor bearing noise are discussed in this paper.

77-715

Diagnostic System for Ball Bearing Quality Control

L.W. Winn and H.L. Bull

Mechanical Technology, Inc., Latham, NY., SAE Paper No. 760910, 12 pp, 5 figs, 4 refs

Key Words: Bearings, Diagnostic techniques, High frequency resonance technique

This paper describes the test and construction of a bearing analyzer which employs the High Frequency Resonance Technique (HFRT) for fault detection and identification. The analyzer consists of a mechanical console on which the test bearing is mounted, loaded, and brought up to speed, and an electronic console which receives bearing vibrations via an accelerometer mounted on the bearing retainer, and processes same to provide a digital unit read-out indicative of bearing condition.

77-716

Eight Ways to Stop Rolling Bearing Failure. Part 2

H. Keire

SKF Industries, Inc., Philadelphia, PA., Power Trans. Des., 18 (12), pp 53-55 (Dec 1976) 9 figs

Key Words: Bearings, Vibration effects

Four causes of bearing failure are discussed: lubrication, sealing, vibration, and electric current.

FACILITIES

77-717

Model Study of a Proposed Engineering Acoustic Research Facility

G.W. Johnston, F. Rueter and M.S. Chappell

Div. of Mechanical Engrg., National Research Council of Canada, Ottawa, Ontario, Canada, Rept. No. DME-ME-243, NRC-15480, 29 pp (July 1976) AD-A030 639/9GA

Key Words: Test facilities, Aircraft noise

A one-twelfth scale aeroacoustic model of a proposed engineering acoustic research facility has been tested to assess the background noise levels in the anechoic measurement area, and to develop a suitable exhaust collector for deflected jet conditions. The facility comprises an open circuit, open jet wind tunnel with an anechoic space surrounding the test section. Collector configurations with acceptably low background noise and low sensitivity to jet deflection have been defined, but these features were achieved at the expense of some aerodynamic efficiency.

77-718

Overspeed Test Facilities of the Group -- Overspeed Testing and Balancing of Large Rotors

W. Kellenberger, H. Weber and H. Meyer

Baden, Switzerland, Brown Boveri Rev., 63, pp 399-411 (June 1976) 14 figs, 5 refs

Key Words: Test facilities, Rotors, Balancing techniques, Overspeed testing, Turbine components

This article presents the philosophy of overspeed testing of large turbines and generators, describes the Brown Boveri Group's facilities and explains the techniques of rotor balancing.

77-719

Sound Power Measurements in Reverberation Chambers

J. Tichy, M.J. Brien and K.P. Roy

Dept. of Architectural Engrg., Pennsylvania State Univ., University Park, PA., Rept. No. NBS-GCR-76-59, 234 pp (Jan 1976)

PB-256 639/6GA

Key Words: Acoustic measurement, Reverberation chambers

Analytic and experimental studies of the effect of moving diffusers on the precision and accuracy of reverberation room measurements are reported. The analytic model involves numerical computations of the sound field produced by a point source in a rectangular room with one moving wall.

INSTRUMENTATION

77-720

A Fully Automatic Torsional Oscillation Testing Instrument with Process-Control Computer Connection

V.G. Wiegand and R. Goldelius

Aachen, Germany, VDI Z., 118 (20), pp 975-981 (Oct 1976) 9 figs, 17 refs

(In German)

Key Words: Test equipment, Torsional vibrations

A torsional oscillation experiment serves for the determination of the modulus of shear and of the mechanical loss factor of a sample in dependency on the temperature. In this manner the numerical characteristics can be determined which describe with high information power the mechanical-thermal behavior of plastics. In comparison to the customary testing instruments, a testing system offers considerable advantages, in which a torsional oscillation experiment as well as the evaluation of measuring results are performed automatically. Such a system is described in this contribution.

77-721

Interferometric Sensor for the Measurement of Vibrations of Mechanical Structures

M. Philbert and G. Dunet

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1975-5 (ESA-TT-298) May 1976, pp 110-137 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, No. 1975-5, Sept-Oct 1975, pp 289-299, N76-32103)

N76-32108

Key Words: Interferometers, Vibration measurement, Blades, Gear boxes

A contactless interferometric sensor for structural vibration measurement was developed. The difficulties inherent in interferences in scattered light, (speckle phenomenon) and the methods used to remedy them, were studied and the sensor and its operation is described. Some experimental results are presented, in particular those for a blade excited torsionally and on a helicopter main gear box.

77-722

The Acoustic Telescope

J. Billingsley and R. Kinns

Dept. of Engrg., Univ. of Cambridge, Cambridge CB2 1PZ, England, J. Sound Vib., 48 (4), pp 485-510 (Oct 22, 1976) 15 figs, 18 refs

Key Words: Test equipment, Noise source identification, Aircraft noise, Jet noise

A system has been developed for real-time sound source location on full-size jet engines. A theoretical analysis of system performance is in terms of a line source of generally correlated omni-directional sound radiators, which shares the measurable far-field properties of a jet engine noise source. The general properties of the system are described, including its use to correlate spatially separated sound sources, application in the presence of ground reflections and use in a moving airstream. The statistical properties of apparent source distributions are also discussed. A series of experiments on a Rolls-Royce/SNECMA Olympus engine is described, in order to illustrate application of the system.

TECHNIQUES

(Also see Nos. 737, 738, 848)

77-723

Survey of European Ground and Flight Vibration Test Methods

H.G. Natke

Technical University Hannover, Germany, SAE Paper No. 760878, 20 pp, 4 figs, 65 refs

Key Words: Vibration tests, Testing techniques, Reviews

The ground and flight vibration test methods of the E.C. which are published and/or used in practice since 1968 are reviewed. The survey contains a short description of the methods, indications with regard to their applications and ensuing experiences, and it reflects many and successful efforts in the field of identification. Ground vibration test methods without a-priori parameter estimation predominate over those with parameter estimation. Only a few methods consider non-linearities. The flight vibration test methods are based exclusively on estimation procedures and much effort is expended to cope with background noise.

77-724

Survey of Modal Vibration Test/Analysis Techniques

R.W. Mustain

Space Div., Rockwell International, SAE Paper No. 760870, 16 pp, 21 refs

Key Words: Testing techniques, Vibration tests, Modal tests, Modal analysis

The results of a survey of modal vibration test/analysis techniques in the United States are presented. Summarized in this paper are responses to a questionnaire distributed to Dynamics engineers involved in modal testing and to members of the *SAE Committee G-5 Aerospace Shock and Vibration*. The survey encompassed the following modal vibration test/analysis requirements: objectives, test specimens, boundary conditions, support/suspension systems, instrumentation, excitation systems, modal testing/analysis excitation methodology, correlation checks, and data processing requirements.

77-725

An Evaluation of Excitation and Analysis Methods for Modal Testing

G.A. Hamma, S. Smith and R.C. Stroud

Lockheed Palo Alto Research Lab., Lockheed Missiles and Space Co., Inc., Palo Alto, CA., SAE Paper No. 760872, 20 pp, 14 figs, 17 refs

Key Words: Testing techniques, Vibration tests, Modal tests

This paper reports on the evaluation of several modal-testing procedures as applied on a modern data-acquisition and -analysis system. These methods include two forms of specimen excitation (sine and muitifrequency) and several methods of modal characterization (analytical curvefitting, multi-shaker modal tuning, and hybrid techniques). The methods are compared, using examples, and a modal testing procedure is suggested.

77-726

Force Appropriation by Extended Asher's Method

P. Ibanez

Applied Nucleonics Co., Inc., SAE Paper No. 760873, 16 pp, 6 figs, 21 refs

Key Words: Testing techniques, Vibration tests, Modal tests

Force appropriation is used in modal vibration testing of complex structures in order to excite one mode of vibration at a time. In this paper several force appropriation algorithms are reviewed and an extension of Asher's method, using impulsive and transient excitation as well as sinusoidal excitation, is developed.

77-727

Identifying Modes of Large Structures from Multiple Input and Response Measurements

M. Richardson and J. Kniskern

Hewlett-Packard Co., SAE Paper No. 760875, 12 pp, 12 figs, 2 refs

Key Words: Testing techniques, Vibration tests, Modal tests

This paper discusses a new testing and data processing technique for obtaining modal parameters which does not require that the transfer function measurements be made using a single excitation or response point. For large structures this "multiple point" testing technique is in many cases, necessary for obtaining measurements of sufficient quality to identify the modes of vibration.

77-728

Application of Unloaded (Free) Motion Measurements and Mechanical Impedance to Vibration Testing

D.O. Smallwood

Sandia Labs., Albuquerque, NM, Rept. No. SAND-75-5790; Conf-760411-2, 12 pp (1976)

Sponsored by ERDA

N76-32585

Key Words: Vibration tests, Mechanical impedance

A method using unloaded (free) motion measurements is reviewed. Several applications are suggested. Also discussed are methods for applying the results to sinusoidal, transient, and random vibrations.

77-729

The Use of Induction Motors as Vibration Generators

T.M. Holdsworth and R.D. Morris

Carrier Corp., Syracuse, NY., S/V, Sound Vib., 10 (11), pp 24-28 (Nov 1976) 7 figs

Key Words: Testing techniques, Vibration testing, Vibrators (machinery), Induction motors

This article describes a vibration excitation technique that was originally developed for measuring the natural frequencies of a fan system in a unit assembly, and which has since proven to be very useful in other vibration and acoustical studies.

77-730

The Vibration Test of an Imperfectly Linear Structure

R. Dat

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1975-4 (ESA-TT-296) May 1976, pp 47-54 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, No. 1975-4, July-Aug 1975, pp 223-227, N76-32097) N76-32101

Key Words: Testing techniques, Vibration tests

Vibration testing of nonlinear structures is discussed. The test methods used for identifying structures are based mainly on the linearity assumption and are inappropriate when the structure tested is imperfectly linear.

77-731

Frequency Response Testing in a Noisy Environment or With a Limited Power Supply

M.F. White and R.G. White

Inst. of Sound and Vibration Res., Univ. of Southampton, Southampton S09 5NH, England, J. Sound Vib., 48 (4), pp 543-557 (Oct 22, 1976) 13 figs, 9 refs

Key Words: Testing techniques, Transient excitation

The use of time domain averaging is demonstrated and it is shown to be a suitable signal enhancement procedure for testing in poor signal to noise ratio conditions, when using a transient excitation technique. The limitations and accuracy of the technique are discussed and examples of practical application are given.

77-732

Computerized Signal Processing for Detecting Cracks under Installed Fasteners

J. Couchman, J. Bell and P. Noronha

General Dynamics, Fort Worth Div., Fort Worth, TX 76101, Ultrasonics, 14 (6), pp 256-262 (Nov 1976) 14 figs, 3 refs

Key Words: Ultrasonic testing, Testing techniques, Computer aided techniques

This paper describes the development work on a computerized system designed to detect cracks by rotating a shear wave transducer around installed fasteners or bolt holes. Two promising methods to compute flaw sizes are also described in this paper.

77-733

Measurement of Structure Borne Wave Intensity. Part 1: Formulation of the Methods

G. Pavic

Electrotechnical Institute "Rade Koncar", 41000 Zagreb, Yugoslavia, J. Sound Vib., 49 (2), pp 221-230 (Nov 22, 1976) 5 figs, 2 refs

Key Words: Measurement techniques, Flexural waves, Wave propagation, Plates

This paper discusses methods for the measurement of structural wave intensities associated with various points in a wave field. The intensity measurements described are for flexural waves since these play an important role in the dynamic behavior of typical structures. The necessary calculations require data obtained purely from the measurement of kinematical quantities. In addition, it is shown how the procedures for intensity measurements can be simplified in some special cases.

77-734

Contour Mapping Applied to OSHA Noise Problems

T.H. Rockwell

Environmental Technology Corp., 30405 Solon Rd., Cleveland, OH 44139, Noise Control Engr., 7 (1), pp 35-38 (July/Aug 1976) 1 fig, 2 refs

Key Words: Industrial noise, Noise reduction, Contour mapping, Noise measurement

A systematic method using noise contour mapping with time-motion data to define an industrial noise environment is discussed in this paper.

77-735

Underwater Explosion Research Using Small Amounts of Chemical Explosives

L. Bjorno and P. Levin

Dept. of Fluid Mechanics, Technical Univ. of Denmark, DK-2800 Lyngby, Denmark, Ultrasonics, 14 (6), pp 263-367 (Nov 1976) 3 figs, 25 refs

Key Words: Underwater explosions, Testing techniques, Model testing

Measurements of pressure waves taken at a short range from the detonation of small amounts of chemical explosives are discussed. Empirical expressions for the peak pressure, time constant, impulse and energy flux density as a function of charge weight and distance are shown.

77-736

Reciprocity Measurement of Acoustical Source Strength in an Arbitrary Surrounding

T. ten Wolde

Institute of Applied Physics TNO-TH, Delft, The Netherlands, Noise Control Engr., 7 (1), pp 16-23 (July/Aug 1976) 8 figs, 10 refs

Key Words: Reciprocal measurement, Acoustic measurement

A reciprocal version of the substitution method is described, which offers advantages over other methods for in situ measurements and measurements at low frequency. Examples indicate the potential of the reciprocal method in these and other conditions, and consider in detail the quality of reciprocity in a system, a primary factor in the method's validity.

HOLOGRAPHY

77-737

Application of Holography to Panel Flutter

D.A. Evensen

J.H. Wiggins Co., Redondo Beach, CA., AIAA J., 14 (12), pp 1671-1674 (Dec 1976) 2 figs, 12 refs

Key Words: Panels, Flutter, Holographic techniques

An analytical approach which outlines the use of holographic interferometry to measure the deflection shape of a fluttering panel is presented. The approach relies on a differential holographic technique which has been demonstrated experimentally on other structures.

77-738

Diversification of Acoustical Holography as a Nondestruct Inspection Technique to Determine Aging Damage in Solid Rocket Motors

H.D. Collins

Holosonics, Inc., Richland, WA., Rept. No. AFRPL-TR-76-37, 117 pp (Apr 1976)

AD-A030 319/8GA

Key Words: Testing techniques, Acoustic holography, Solid propellant rocket engines

The feasibility of using acoustical holography as a nondestructive technique for determining small innerbore cracks and debonds in larger solid rocket motors is demonstrated. Acoustic attenuation in TITAN III C type propellant was measured. Off axis scanning and concentric axial scanning were investigated.

COMPONENTS

SHAFTS

77-739

Dynamics of High-Speed Cam Mechanisms with Damped Flexible Followers Driven by Flexible Camshafts

D. Ardayfio

Univ. of Science and Technology, Kumasi, Ghana, ASME Paper No. 76-DET-63

Key Words: Cams, Camshafts, Shock response spectra

The dynamic response of a damped flexible cam follower, taking into account the flexibility of the camshaft, is investigated. The response characteristics are obtained in terms of the primary and residual shock response spectra (SRS). Numerical results are presented in three-dimensional charts to portray the effect of the various design parameters on the response. Three different cam motion profiles are used.

BEAMS, STRINGS, RODS

(Also see Nos. 678, 687, 693, 800)

77-740

Motion of a Rigid Plastic Cantilever in a Damping Medium Under Transverse Impact

S.A. Ramu and P.N. Rao

Dept. of Civil Engrg., Indian Inst. of Science, Bangalore 12, India, Intl. J. Nonlinear Mech., 11 (6), pp 355-364 (1976) 8 figs, 7 refs

Key Words: Cantilever beams, External damping, Moving loads, Shock loads

The motion of a rigid plastic cantilever beam which is surrounded by a damping medium and struck transversely at the tip by a moving mass is studied. The elementary theory, which disregards effects due to rate of straining and geometry changes is used. The governing equations of motion are integrated numerically. For comparison the case of discrete damping provided at the tip only is also solved. Results are presented for a wide range of parameters.

77-741

Technology Transfer in the Vibration Analysis of Linearly Tapered Cantilever Beams

H.H. Mabie and C.B. Rogers
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA., J. Engr. Indus., Trans. ASME, 98 (4), pp 1335-1341 (Nov 1976) 26, figs, 15 refs

Key Words: Cantilever beams, Variable cross section, Natural frequencies

Curves are presented for determining the fundamental frequency and several higher harmonics for cantilever beams linearly tapered in the vertical or the horizontal plane or tapered in both planes simultaneously (double taper); both the single-tapered and the double-tapered beams are treated with free end, end mass, and end support.

77-742

Shear and Rotary Inertia Effect on Beck's Column

A. Kounadis and J.T. Katsikadelis
National Technical Univ., Athens, Greece, J. Sound Vib., 49 (2), pp 171-178 (Nov 22, 1976) 5 figs, 15 refs

Key Words: Cantilever beams, Flutter, Transverse shear deformation effects, Rotary inertia effects

In this paper the influence of transverse shear deformation and rotatory inertia upon the flutter load of Beck's column with various support characteristics for a variety of slenderness ratios and cross-sectional shapes is presented.

77-743

Dynamic Stability of Timoshenko Beams by Finite Element Method

J. Thomas and B.A.H. Abbas
Mechanical Engrg. Dept., Univ. of Surrey, Guildford, Surrey, England, J. Engr. Indus., Trans. ASME, 98 (4), pp 1145-1151 (Nov 1976) 10 figs, 12 refs

Key Words: Beams, Dynamic buckling, Timoshenko theory, Rotary inertia effects, Transverse shear deformation effects, Finite element technique

A finite element model is developed for the stability analysis of Timoshenko beam subjected to periodic axial loads. The effect of the shear deformation on the static buckling loads is studied by finite element method. The results obtained show excellent agreement with those obtained by other analytical methods for the first three buckling loads. The effect of shear deformation and for the first time the effect of rotary inertia on the regions of dynamic instability are investigated. The elastic stiffness, geometric stiffness, and inertia matrices are developed and presented in this paper for a Timoshenko beam.

77-744

Transverse Vibration of a Uniform, Simply Supported Timoshenko Beam Without Transverse Deflection

B. Downs
Dept. of Mech. Engrg., Loughborough Univ. of Tech., Loughborough, Leicestershire, LE11 3TU, England, J. Appl. Mech., Trans. ASME, 43 (4), pp 671-674 (Dec 1976) 3 figs, 9 refs

Key Words: Beams, Timoshenko theory, Transverse shear deformation effects, Rotary inertia effects, Vibration response

An additional solution is obtained for the vibrational behavior of a uniform, simply supported Timoshenko beam. The characteristics of the mode are explained in physical terms.

77-745

Optimization of Continuous One-Dimensional Structures Under Steady Harmonic Excitation

E.H. Johnson, P. Rizzi, H. Ashley and S.A. Segenreich
NASA, Ames Research Center, Moffett Field, CA., AIAA J., 14 (12), pp 1690-1698 (Dec 1976) 14 figs, 18 refs

Key Words: Cantilever beams, Minimum weight design, Harmonic excitation

To illustrate the minimum -weight design of one-dimensional, elastic structures under dynamic excitation, methods from optimal control theory are applied to the cantilever bar driven sinusoidally by an axial force at its tip. Other directly analogous problems are identified, and closely related cases are discussed in this paper along with practical applications.

77-746

Three Dimensional Added Mass of a Vibrating Ship

Y. Tein
Ph.D. Thesis, The Univ. of Michigan, 103 pp (1976) UM 76-27, 604

Key Words: Ships, Beams, Vibration response

In this paper a general method for calculating the three-dimensional flow about a vibrating ship hull is developed by using the potential flow theory. The "Double-Hull" concept is adopted by assuming that the vibrating frequencies are high. The boundary value problem is linearized with respect to the vibration amplitude. By assuming the hull geometry varies slowly in the axial direction, the solution to the exact boundary value problem is written in terms of a sequence of one-dimensional Fredholm integral equations of the second kind, from which a surface source density distribution is found iteratively.

77-747

Second Order Differential Systems with Applications to Vibrating Beam Problems

S. Cheng

Ph.D. Thesis, Univ. of California, Davis, 66 pp (1976)

UM 76-28, 961

Key Words: Beams, Vibration response

Two-point boundary and eigenvalue problems for a class of second order linear differential systems are investigated through establishing various comparison theorems, oscillation and disconjugacy criteria. Then as applications, a class of fourth order nonselfadjoint differential equations that arose in connection with the lateral vibrations of supported beams is studied.

77-748

Moving Loads on Elastically-Supported Beams

T.A. Apaydin

Ph.D. Thesis, Virginia Polytechnic Inst. and State University, 100 pp (1976)

UM 76-24, 311

Key Words: Beams, Elastic foundations, Moving loads, Harmonic analysis

The dynamic responses of the simply-, elastically-, and system of elastically-supported beams on an elastic foundation subjected to moving concentrated loads are obtained by means of the harmonic analysis method. The response of a simply-supported beam of a finite length on an elastic foundation carrying moving concentrated loads is scrutinized and used to obtain closed-form approximate solutions for elastically- and system of elastically-supported beams. Numerical examples are given in order to investigate the effects of various parameters on the dynamic response of the beams.

77-749

Vibration Analysis of Linearly Tapered Beams Using Frequency-Dependent Stiffness and Mass Matrices

A.K. Gupta

Ph.D. Thesis, Utah State Univ., 153 pp (1975)

UM 76-25, 608

Key Words: Beams, Variable cross section, Vibration response, Rotary inertia effects, Matrix methods

The influence of dynamic correction stiffness and inertia matrices on the vibration of linearly tapered beams has been investigated in this study. The static stiffness and consistent-transverse and rotary inertia matrices have been derived in explicit form for the linearly tapered beam elements of almost all the cross-sectional shapes. Dynamic correction stiffness and consistent-mass matrices have been derived in explicit form for the beam element of closed box or I-section only. These matrices were derived by finite element method using exact expressions for the required displacement functions. Variation of the area and moment of inertia of cross section along the axis of the element is exactly represented by simple functions, involving shape factors. Vibration analysis of beams with various end conditions was performed by a computer program. Numerical results were obtained using the derived matrices and compared with the available analytical solutions and the approximate solutions based upon stepped representation of the beams using uniform elements. The significance of the severity of taper within beams upon solution accuracy and convergence characteristics is examined. A discussion of the comparative costs and advantages and disadvantages of the quadratic and conventional matrix formulation is also given.

77-750

Moving Mass on Structures (Beam, Plate, Shell)

R. Raghavan

Ph.D. Thesis, Virginia Polytechnic Inst. and State University, 143 pp (1974)

UM 76-24, 338

Key Words: Beams, Plates, Shells, Moving loads

A technique has been presented in this paper, to obtain the solutions of the differential equation of motion, which govern the dynamic response of beams, plates and shells, subjected to moving masses. To illustrate the procedure, the particular case of simply supported end conditions was used. The load consists of nonelastic wheel type mass, together with a pulsating driving force. The mass is assumed to move either in an arbitrary linear path with a constant velocity or in a cyclic path with respect to any arbitrary point on the elastic structure.

77-751

On the Behavior of Linear Undamped Elastic Systems Perturbed by Follower Forces

E.F. Infante and J.A. Walker
Lefschetz Center for Dynamical Systems, Brown Univ., Providence, RI., 14 pp (1976) (presented at Intl. Symp. on Dynamical Systems, Gainesville, FL., Mar 1976)
AD-A030 183/8GA

Key Words: Rods, Dynamic response, Follower forces

Beck's Problem is one of many non-conservative problems encountered in the theory of elastic structures; the problem is called nonconservative in that the total energy is not necessarily constant given the follower nature of the load. This problem is investigated and discussed in this paper.

77-752

Vibrations of a Rotating Flexible Rod Clamped Off the Axis of Rotation

W.D. Lakin
Dept. of Mathematics, Univ. of Toronto, Toronto, Canada M5S 1A1, J. Engr. Math., 10 (4), pp 313-321 (Oct 1976) 2 figs, 8 refs

Key Words: Rods, Boundary value problems

A fourth-order boundary value problem associated with the small vibrations of a uniform flexible rod which is clamped at one end and rotates in a plane perpendicular to the axis of rotation is considered. A significant feature is that the axis of rotation does not pass through the clamped end itself. For rapid rotation rates, the governing equation involves a small parameter and must be treated by singular perturbation techniques. A second parameter fixes the relative location of two turning points. For a range of this second parameter, consistent approximations to the characteristic equation are derived, and the limiting behavior of the eigenvalues is obtained.

77-753

Response of a String to an Accelerating Mass

R. Rodeman, D.B. Longcope and L.F. Shampine
App. Mechanics Div. 1281, Sandia Laboratories, Albuquerque, NM., J. Appl Mech., Trans. ASME, 43 (4), pp 675-680 (Dec 1976) 4 figs, 9 refs

Key Words: Cables (ropes), Strings, Moving loads

The response of a string to a mass particle undergoing a constant horizontal acceleration from rest has been calculated. The string deflection is expressed in terms of the transverse mass motion. A delay-differential equation is solved both numerically and asymptotically for the mass velocity. String profiles are presented at subsonic and supersonic speeds. Two oppositely traveling jumps in string displacement are found to appear as the mass is accelerated through the wave speed of the string.

77-754

Cable Dynamics -- A Finite Segment Approach

J.M. Winget and R.L. Huston
Dept. of Engrg. Analysis, Univ. of Cincinnati, Cincinnati, OH 45221, Computers and Struc., 6 (6), pp 475-480 (Dec 1976) 7 figs, 27 refs

Key Words: Cables (ropes), Mathematical models, Finite element tehcnique

The paper presents and discusses a nonlinear, three-dimensional, finite-segment, dynamic model of a cable or chain. The model consists of a series of links connected to each other by ball-and-socket joints. The size, shape, and mass of the links is arbitrary. Furthermore, these parameters may be distinct for each link. Also, the number of links is arbitrary. The model allows an arbitrary force system to be applied to each link. The model is used to develop a computer code which consists primarily of subroutines containing algorithms to develop the kinematics, force systems, and governing dynamical equations. Although the integration of the equations is performed with a Runge-Kutta algorithm, the code is developed so that any other suitable integration technique or algorithm may be substituted. An example problem is presented which describes the motion of a sphere drug through water by a partially submerged cable suspended from a rotating surface crane. Viscous forces of the water are included. Although the example simulates a typical nautical rig, its inclusion in the paper is introduced primarily to illustrate the capability of the model.

BEARINGS

(See Nos. 713, 714, 715, 716, 811)

BLADES

(Also see Nos. 721, 846)

77-755

Soil Excavation Improvement from Bulldozer Blade Oscillation

J.M. Brown

State Engrg. Industrial Res. Station, Mississippi State Univ., MS., Rept. No. MSSU/EIRS/ME-77-1, 250 pp (July 30, 1976)
AD-A030 028/5GA

Key Words: Construction equipment, Excavations, Blades

The results of research to determine the feasibility of oscillating a bulldozer blade to improve productivity are reported. In particular, the research was directed toward determining the optimum oscillating mass, frequency, amplitude, and direction; to determine the power required for oscillation; and to conceive practical configurations which could be integrated into a dozer and which would prevent the oscillation from damaging the tractor.

77-756

Frequencies and Mode Shapes in Jet Engines

M. Lalanne and C. Zabukovec

I.N.S.A. Laboratoire de Mecanique des Structures, Cedex, France, ASME Paper No. 76-DET-89

Key Words: Blades, Natural frequencies, Mode shapes, Jet engines

The calculation of frequencies and mode shapes for jet engines is discussed, and a specific example of a structure of axisymmetric type is presented in detail, with particular emphasis on the evaluation of an improved design.

COLUMNS

(See No. 737)

CYLINDERS

(See Nos. 694, 695)

DUCTS

77-757

Boundary Layer Considerations for Optimization of Acoustic Liners for Aircraft Engine Ducts

R.A. Prydz

Lockheed-California Co., SAE Paper No. 760896, 20 pp, 15 figs, 10 refs

Key Words: Ducts, Acoustic linings, Aircraft engines

This paper presents a study of the effects of shear flow on the sound attenuation in lined ducts. The main emphasis is on proper selection of liner impedance for optimum attenuation performance of the acoustic liner in the presence of realistic duct boundary layer flows. Results are given for arbitrary spinning acoustic propagation modes, and combinations of modes in treated inlet and exhaust ducts for a variety of simple boundary layer velocity profiles and boundary layer thicknesses.

77-758

Sound Attenuation in Ducts Lined on Two Opposite Walls with Porous Material, With Some Applications to Splitters

A. Cummings

Dept. of Environmental Science and Technology, Polytechnic of the South Bank, London SE1 0AA, England, J. Sound Vib., 49 (1), pp 9-35 (Nov 8, 1976) 19 figs, 21 refs

Key Words: Ducts, Noise reduction, Acoustic linings, Hole-containing media

A theory is given for acoustic attenuation in ducts lined on two opposite sides with porous sound-absorbing material incorporating perforated facings, in the presence of uniform flow. Theoretical calculations are compared to measurements by the author, and to experimental data in the literature. Some emphasis in the discussion is placed on three-dimensional higher order modes of propagation. The application of the model to splitter type silencers is discussed, and design curves for duct linings are given.

77-759

Prediction of the Acoustic Impedance of Duct Liners

W.E. Zorumski and B.J. Tester

NASA, Langley Res. Center, Langley Station, VA., Rept. No. NASA-TM-X-73951, 65 pp (Sept 1976)
N76-31979

Key Words: Ducts, Acoustic linings, Acoustic impedance

Recent research which contributes to the prediction of the acoustic impedance of duct liners is reviewed. This review includes the linear and nonlinear properties of sheet and bulk type materials amd methods for the measurement of these properties. It also includes the effect of grazing flow on the acoustic properties of materials. Methods for predicting the properties of single or multilayered, point reacting or extended reaction, and flat or curved liners are discussed.

77-760

An Experimental Study of Swinbanks' Method of Active Attenuation of Sound in Ducts

J.H.B. Poole and H.G. Leventhall
Dept. of Physics, Chelsea College, Pulton Place, London SW6 5PR, England, J. Sound Vib., 49 (2), pp 257-266 (Nov 22, 1976) 9 figs, 5 refs

Key Words: Ducts, Acoustic absorption, Active isolation

The concept of attenuating sound propagating down a duct by means of an antiphase copy of the sound was first put forward forty years ago, but to date no practical system has been produced. The principal problem is to introduce the anitphase signal in such a way that it propagates only in the direction of propagation of the original sound and to ensure that this property can be maintained over a useful frequency range. A unidirectional array of secondary sources has been successfully constructed around a rectangular duct, using loudspeaker drive units and electronic delays. Sound propagating in the direction of these sources was sampled and a control signal applied to the sources which in turn acted to significantly reduce the amplitude of the sound. Pure tones at frequencies around 150 Hz have been attenuated by more than 50 dB but results with band-limited noise have been less successful. Further work is suggested which should result in a device having significant advantages over conventional splitter silencers, at low frequencies.

77-761

Theory and Measurement of Acoustic Wave Propagation in Multi-Segmented Rectangular Flow Ducts

R.E. Kraft
Ph.D. Thesis, Univ. of Cincinnati, 271 pp (1976)
Sponsored by NASA
UM 76-25, 127

Key Words: Ducts, Noise reduction

The primary objective of this study is the development of analytical and experimental techniques which examine the finer details of the propagation processes, and the unification of these techniques into a verified method of treatment design which optimizes the suppression of noise under a given set of constraints. The basic theory of flow duct acoustics for ducts of rectangular cross section is presented. The nature of the boundary condition is considered in detail and a numerical method is developed for determining the eigenvalues. A generalized theory of orthogonality for boundary value problems with eigenvalue-dependent boundary conditions is developed to justify the expansion of arbitrary functions in series of eigenfunctions.

FRAMES

(Also see No. 678)

77-762

Dynamic Buckling of Shallow Arches

D.L.C. Lo and E.F. Masur
Fast Breeder Reactor Dept., General Electric Co., Sunnyvale, CA., ASCE J. Engr. Mech. Div., 102 (EM5), pp 901-917 (Oct 1976)

Key Words: Arches, Dynamic buckling

When a shallow arch is subjected to a symmetric dynamic load, this load becomes "critical" if a slight increase in the load magnitude leads to a sudden snap-through. Another form of instability occurs when a slight antisymmetric component in the load produces a sharply increasing antisymmetric response. Both forms of instability are investigated by means of a numerical procedure which introduces a finite element technique into an integro-differential equation formulation.

77-763

Large Deformations of Framed Structures Under Static and Dynamic Loads

C. Oran and A. Kassimali
Civil Engrg. Dept., Univ. of Missouri-Columbia, Columbia, MO 65201, Computers and Struc., 6 (6), pp 539-547 (Dec 1976) 10 figs, 14 refs

Key Words: Framed structures, Beam-columns, Dynamic response

With reference to the problem of large deformations and stability of elastic framed structures, this paper explores the computational capabilities of a general beam-column type method which was recently developed by the senior author. The method is flexible in that the coordinate system used may be either Eulerian or Lagrangian. In addition, various types and levels of consistent approximations can be introduced into the analysis in a rather routine fashion.

GEARS

(See No. 721)

MEMBRANES, FILMS, AND WEBS

77-764

An Experimental Study of the Static and Dynamic Behaviour of a Tensioned Sheet with a Rectangular Opening

P.K. Datta
Indian Inst. of Technology, Kharagpur, India, Aeronaut. Quart., 27 (4), pp 257-262 (Nov 1976) 7 figs, 10 refs

Key Words: Hole-containing media, Vibration tests

The results of an experimental study of the buckling and vibration behavior of tensioned sheets with a rectangular opening are presented. The buckling phenomenon involves the existence of a non-uniform pre-buckle stress state in the vicinity of the opening. The local buckling load has been estimated on the basis of the modified Southwell method.

PANELS

(Also see No. 679)

77-765

Dynamic Modeling of Large Precast Panel Buildings Using Finite Elements with Substructuring

R.A. Frank, J.M. Becker and J.M. Biggs
Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA., Rept. No. MIT-CE-R76-36, 166 pp (Aug 1976) (see also Rept. No. 1, PB-252 852) PB-257 220/4GA

Key Words: Buildings, Panels, Precast concrete, Earthquake resistant structures

There is presently little known about the dynamic behavior of Large Precast Panel Building (LPPB) systems. This report is a preliminary investigation of the dynamic response characteristics of these systems. The structure is assumed to respond elastically and is modeled using statically condensed super elements to represent the panels and anisotropic finite elements to model the connections.

77-766

Dynamics of Composite and Sandwich Panels. Part II

C.W. Bert
School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73069, Shock Vib. Dig., 8 (11), pp 15-24 (Nov 1976) 109 refs

Key Words: Panels, Composite structures, Sandwich structures, Flexural vibration, Elastic properties, Viscoelastic properties

This article surveys the literature pertaining to the dynamics of composite and sandwich panels and emphasizes flexural motion. It is limited to elastic and viscoelastic behavior of materials. Free vibration work since 1969 is emphasized. Plates stiffened with attached stiffeners (stringers) and curved panels (as opposed to flat ones) are beyond the scope of the survey. The author has concentrated on references available from the National Technical Information Service.

PIPES AND TUBES

(Also see No. 787)

77-767

On the Problem of Wrapping and Lagging Noisy Piping

D.H. McQueen
10 George Road, Winchester, MA 01890, Acustica, 35 (4), pp 316-320 (Aug 1976)

Key Words: Pipes (tubes), Noise reduction, Absorbers (materials), Sound transmission loss

The theoretical basis of acoustic wrapping and lagging is discussed in terms of the mathematically defined insertion loss and transmission loss of barriers. The general theory is applied specifically to the problem of choosing appropriate conditions for measurement of the insertion loss of wrapping and lagging applied to standard steel pipes. Some practical guidelines are given.

77-768

Comparative Methods for Analysis of Piping Systems Subjected to Seismic Motion

D. Hure and M. Morysse
Experimental Res. Section, Bureau Veritas, Paris - XVII, France, Nucl. Engr. Des., 38 (3), pp 511-525 (Sept 1976) 15 figs, 4 refs

Key Words: Piping systems, Nuclear power plants, Seismic response, Finite element technique

The dynamic analysis of a three-dimensional piping system of a nuclear power plant is conveniently performed through a finite element method. When the modal analysis is used, only the first few modes of vibration are computed for practical purposes. In this paper, a method of residues is proposed which evaluates the neglected modes and combines them with the first calculated modes to estimate the total seismic response of the piping. This method emphasizes the importance of the selected modes. When the approach is made through a time history input function, this latter is usually characterized by a combination of several recorded accelerograms, e.g., El Centro, San Francisco and Taft. The response of a particular piping has been evaluated by means of these two methods: the use of the modal approach will be strongly recommended due to its inherent advantage of economy and also computation time and reliability.

77-769

Dynamic Characteristics of Heat Pipes

G. Rice and E. Azad
Engineering and Cybernetics Dept., Reading Univ., England, In: ESA Heat Pipes, pp 153-164 (1976) (N76-32374)
N76-32388

Key Words: Pipes (tubes), Fluid-induced excitation, Thermal excitation

The dynamic response of a heat pipe at start-up or variable thermal input under buffered conditions relates to various properties of the working fluid. Both water and sodium charged heat pipes were tested with air and helium buffering, respectively. The experimental determination of dynamic response of each heat pipe, under varying operating conditions, was compared to theoretical predictions.

PLATES AND SHELLS

(Also see Nos. 693, 733, 750, 822)

77-770

Damping Properties of Layered Cylindrical Shells, Vibrating in Axially Symmetric Modes

Š. Markuš
Inst. of Machine Mechanics, Slovak Academy of Sciences, 809 31 Bratislava -- Patronka, Czechoslovakia, J. Sound Vib., 48 (4), pp 511-524 (Oct 22, 1976) 8 figs, 15 refs

Key Words: Cylindrical shells, Viscoelastic damping

The damping of cylindrical shells coated with unconstrained layers of viscoelastic material either on one side of the shell (inside or outside) or on both sides is estimated. The basic equations of motion are derived which describe harmonic forced flexural damped vibrations in axisymmetric modes. For pure sinusoidal modes expressions for the overall loss factors are given. The damping properties of cylindrical shells of finite length, coated on the inside or outside, or on both sides (symmetrically or unsymmetrically) are compared. Classical thin shell theory is used for the analysis. It is shown how two-layered damped shells differ from two-layered damped beams. The extent of damping reduction in shells resulting from the fact that the shell cross-section is closed is discussed.

77-771

Finite Element Method Applied to the Supersonic Flutter of Circular Cylindrical Shells

M.N. Bismarck-Nasr
EMBRAER, Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Sao Paulo, Brazil, Intl. J. Numer. Methods Engr., 10 (2), pp 423-435 (1976) 4 figs, 23 refs

Key Words: Cylindrical shells, Flutter, Finite element technique

The application of the finite element method to the supersonic flutter of circular cylindrical shells subjected to internal pressure and axial compression is presented. A circular cylindrical shell element is used. The element stiffness, mass and initial stiffness matrices are given. The element aerodynamic matrix is derived based on a first order high Mach number approximation to the linear potential flow theory. The eigenvalue problem is solved by the QR algorithm. Numerical results are presented and these are compared with analytical solutions and experimental data.

77-772

Moving Loads on Elastic Cylindrical Shells

C.C. Huang

Dept. of Mechanical Engrg., Univ. of Western Australia, Nedlands, Western Australia 6009, Australia, J. Sound Vib., 49 (2), pp 215-220 (Nov 22, 1976) 4 figs, 9 refs

Key Words: Cylindrical shells, Moving loads, Periodic response

This paper presents a theoretical analysis of the axially-symmetric, steady-state response of a linearly-elastic, homogeneous, infinitely-long, cylindrical shell, subjected to a ring load traveling at a constant velocity. The Fourier transform method in conjunction with the contour integral has been applied to obtain the steady-state response. A numerical illustration is given.

77-773

The Frequency of Inertial Waves in a Rotating, Sectored Cylinder

W.E. Scott

Ballistic Research Laboratories, The Johns Hopkins Univ., Baltimore, MD., J. Appl. Mech., Trans. ASME, 43 (4), pp 571-574 (Dec 1976) 1 fig, 9 refs

Key Words: Cylindrical shells, Fluid-filled containers, Natural frequencies

An analysis of the inertial wave eigenfrequencies of a rapidly rotating liquid in a cylinder whose cross section is divided into four 90 deg sectors reveals that only if the cylinder height is less than the cylinder diameter can the fundamental frequencies be of the order of magnitude of the frequencies of spin-stabilized projectiles. Hence, sectoring the usual long cavities in liquid-filled, spin-stabilized projectiles will preclude the occurrence of a "Stewartson" resonance.

77-774

Dynamics of a Paritally-Filled Cylinder

D.R. Tichenor

Ph.D. Thesis, Univ. of Missouri-Rolla, 83 pp (1976) UM 76-26, 872

Key Words: Cylindrical shells, Fluid-filled containers, Sloshing

In this investigation a series of three problems involving the motion of partially full, thin-walled, circular cylinders which roll without slipping on plane surfaces is treated analytically.

77-775

The Vibrations of an Infinite Orthotropic Layered Cylindrical Viscoelastic Shell in an Acoustic Medium

B.S. Berger

Dept. of Mech. Engrg., Univ. of Maryland, College Park, MD., J. Appl. Mech., Trans. ASME, 43 (4), pp 668-670 (Dec 1976) 4 figs, 15 refs

Key Words: Cylindrical shells, Fluid-induced excitation

In the following a numerical solution is given for the vibration of an orthotropic layered cylindrical viscoelastic shell in an acoustic medium. The acoustic fluid is modeled through a finite-difference scheme. Numerical results for the elastic shell in an acoustic medium agree with previous solutions.

77-776

Numerical Fluid Loading Coefficients for the Modal Velocities of a Cylindrical Shell

B.E. Sandman

Naval Underwater Systems Center, Newport, RI 02840, Computers and Struc., 6 (6), pp 467-473 (Dec 1976) 7 figs, 13 refs

Key Words: Cylindrical shells, Fluid-induced excitation, Submerged structures

The generalized fluid loading coefficients for the modal velocities of a simply-supported shell section are defined and formulated. The simplified nature of infinite cylindrical coordinates is employed in the geometry of interaction by assuming the predominance radial effects in a baffled extension of the finite shell. An efficient numerical procedure for the computational evaluation of the integrals which define the direct and cross mode components of the fluid impedance is presented and applied. The approach and illustrated results are directly applicable in the combined solution of shell and fluid interaction problems.

77-777

The Free Vibrations of Elastically Connected Circular Plate Systems with Elastically Restrained Edges and Radial Tensions

S. Chonan

Dept. of Mechanical Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 49 (1), pp 129-136 (Nov 8, 1976) 3 figs, 5 refs

Key Words: Circular plates, Natural frequencies

The free vibrations of elastically connected circular plate systems with elastically restrained edges and initial radial tensions are investigated analytically. By using the equations developed for the general n-plate system, the plate systems consisting of three and two identical plates with identical boundary conditions and a uniform radial tension are treated in detail. Both axisymmetric and non-axisymmetric vibrations are considered. Attention is directed to the influence of the radial tension and the elastic edge constraints on the first nine eigenvalues and the corresponding natural frequencies of the systems.

77-778

A Reduction Method for Vibrating and Buckling Problems of Orthotropic Continuous Plates

T. Sakata

Dept. of Mechanical Engrg., Chubu Inst. of Tech., Kasugai, Nagoya-sub., Japan 487, J. Sound Vib., 49 (1), pp 45-52 (Nov 8, 1976) 1 fig, 13 refs

Key Words: Plates, Natural frequencies, Reduction methods

It is shown that the natural frequency and buckling force of an orthotropic continuous plate subject to bi-axial in-plane forces can be estimated from those of an isotropic continuous plate with the same boundary conditions by using the reduction formula derived in the present paper. The correlation between the natural frequency of an orthotropic continuous plate and the in-plane force acting on the plate is exactly derived from the reduction formula. Several numerical calculations are performed to justify the reduction method and the correlation proposed here.

77-779

Free Flexural Vibration of Initially Imperfect Thin Plates with Large Elastic Amplitudes

Z. Celep

Z. Angew. Math. Mech., 56 (9), pp 423-428 (Sept 1976) 10 figs, 9 refs

Key Words: Plates, Rectangular plates, Flexural vibrations

Approximate solutions for the free flexural vibration of initially imperfect thin rectangular plates with large deflections are presented with four boundary conditions. The effects of large amplitudes and initial imperfections on the vibration are investigated. Numerical results represented in figures make these effects more clear.

77-780

A Thick Finite Strip Solution for Static, Free Vibration and Stability Problems

P.R. Benson and E. Hinton

Dept. of Civil Engrg., University College of Swansea, Swansea, Wales, Intl. J. Numer. Methods Engr., 10 (3), pp 665-678 (1976) 6 figs, 24 refs

Key Words: Plates, Finite strip method

A finite strip method for the analysis of plate bending problems is described. This method, which takes into account the effects of transverse shear deformation, is applied to the static analysis of a curved plate and then to the free vibration and stability of thick and thin plates.

77-781

The Flexural Vibration of a Line-Stiffened Plate with Fluid Loading. Part 1: Analysis

V. Williams and F.J. Fahy

Institute of Sound and Vibration Research, Univ. of Southampton, Southampton S09 5NH, England, J. Sound Vib., 49 (2), pp 161-169 (Nov 22, 1976) 2 figs, 9 refs

Key Words: Plates, Flexural vibration, Fluid-induced excitation

This paper considers the vibration of a symmetrical system consisting of an infinite fluid loaded plate bearing a finite number of parallel stiffeners. The system is driven at the central stiffener by a travelling wave line force. Formal solutions for the equations of motion are found in terms of cosine transforms. Manipulation of the equations allows the problem to be reduced to the solution of a set of linear algebraic equations in the vibration amplitudes at the stiffeners. The coefficients in these equations depend in a simple way upon the stiffener parameters, and upon particular values of the cosine transform of a function which depends only on the plate and fluid parameters, and the stiffener positions.

77-782

The Use of Power Flow Methods for the Assessment of Sound Transmission in Building Structures

B.M. Gibbs and C.L.S. Gilford

Dept. of Construction and Environmental Health, Univ. of Aston in Birmingham, Birmingham B4 7ET, England, J. Sound Vib., 49 (2), pp 267-286 (Nov 22, 1976) 25 figs, 19 refs

Key Words: Walls, Plates, Sound transmission

A description is given of a versatile method of analysis of noise transmission in buildings. This method incorporates power flow techniques and has the advantage that a unified approach is possible to both the direct and indirect transmission paths and is therefore equally applicable to transmission between rooms which are adjacent or several rooms or floors apart.

77-783

Random Vibration of Compliant Wall

J. Yang and R.A. Heller

Dept. of Civ., Mech., and Environmental Engrg., George Washington Univ., Washington, D.C., ASCE J. Engr. Mech. Div., 102 (EM6), pp 1041-1057 (Dec 1976)

Key Words: Walls, Plates, Random excitation

A random vibration analysis for the response of a compliant wall, consisting of an elastic base plate, a low modulus viscoelastic substrate and stretched skin, subjected to turbulent boundary layer excitation is presented. Compliant walls have the potential to reduce aerodynamic drag in flight vehicles. The cross-power spectral density of surface displacement is calculated as a function of design variables. Three examples are presented and their response statistics are examined in relation to wave drag and roughness drag.

RINGS

(See No. 822)

STRUCTURAL

(Also see Nos. 673, 674, 765, 782, 783)

77-784

Problems of Impact Testing of Floors

L. von Cremer

Institut fuer Technische Akustik der Technischen Universität, Berlin, Acustica, 36 (3), pp 173-183 (Nov 1976) 11 figs, 19 refs

(In German)

Key Words: Floors, Impact tests, Acoustic tests

The problems of impact testing of floors are discussed. Shaker impedance, elastic layer mounting, and nonlinear material mountings are reviewed.

77-785

Response of Equipment in Nuclear Power Plants to Airplane Crash

M. Schalk and H. Wölfel

Ingenieurbüro Dr.-Ing. H. Wölfel, D-8706 Würzburg-Hochberg, Federal Republic of Germany, Nucl. Engr. Des., 38 (3), pp 567-582 (Sept 1976) 28 figs

Key Words: Nuclear power plants, Collision research (aircraft), Floors

Nuclear power plants in Germany are to be designed against airplane crash. A comparison with the results of earthquake loading is given. Suggestions are made for developing suitable floor design spectra and using them to analyze multi-degree-of-freedom systems. However, the paper gives only a partial answer to the questions arising because of some important restrictions which had to be made.

77-786

Structure-Borne Noise of Concrete Floors on Grade

E.L. Wegscheid and W.F. Smith

Deere & Company, Moline, IL., S/V, Sound Vib., 10 (11), pp 30-36 (Nov 1976) 12 figs, 9 refs

Key Words: Floors, Concretes, Vibration effects, Sound transmission

A method to calculate the noise levels generated by a vibrating concrete slab floor has been developed. Noise levels calculated using this method show very good agreement to noise levels actually measured. The method requires an estimate of the absorption properties of the room which encloses the floor, an estimate of the radiation ratio of the floor, and a measurement of the floor vibration levels.

77-787

The Influence of a Partition Wall on the Radiation of Water-Pipe Noise

K. Gosele and C.A. Voigtsberger

Fraunhofer-Gesellschaft, Institut fuer Bauphysik, Stuttgart, Acustica, 35 (4), pp 310-315 (Aug 1976) 7 figs, 11 refs

(In German)

Key Words: Walls, Sound transmission, Water pipelines, Pipes (tubes)

The sound radiation of various heavy partition walls is investigated, when set in motion by water pipes fastened on the walls.

SYSTEMS

ABSORBER

(See Nos. 690, 691)

NOISE REDUCTION

(Also see Nos. 662, 663, 665, 767, 786, 791, 792, 793, 794, 813, 815, 831, 832, 833, 842, 843)

77-788

Calculations on the Sound Reflection from Periodically Uneven Surfaces of Arbitrary Profile

Y. Ando and K. Kato

Dept. of Engineering, Kobe Univ., Kobe, Japan 657, Acustica, 35 (4), pp 321-329 (Aug 1976) 7 figs, 8 refs

Key Words: Noise reduction, Sound transmission, Acoustic absorption

An approximate solution is worked out for the problem of sound reflection when a plane wave is obliquely incident upon an absorbing periodically uneven surface of arbitrary profile. A simultaneous infinite system of linear equations is derived according to the number of the rectangular regions. The equation with the field amplitudes is solved by replacing the system by a finite system. From the solutions, the total reflection factor and the reflecting transfer function at a space point are obtained.

77-789

Control of Industrial Wood Planer Noise Through Improved Cutterhead Design

J.S. Stewart and F.D. Hart

Noise Control Services, Inc., P.O. Box 5467, Greensboro, NC 27403, Noise Control Engr., 7 (1), pp 4-9 (July/Aug 1976) 8 figs, 12 refs

Sponsored by the National Institute for Occupational Safety and Health

Key Words: Woodworking machines, Noise reduction, Design techniques

In this article, a machine design approach noise control in the wood planing operation is described. A design for a new helical cutterhead is presented. The theoretical equation, design relationships, and experimental field results which were part of the development process are reported.

ACTIVE ISOLATION

(See No. 760)

AIRCRAFT

(Also see Nos. 659, 660, 661, 662, 663, 673, 674, 717, 722, 756, 757)

77-790

Nonstationary Random Pulses Representation of Ground Roughness for Taxiing Aircraft

R.P. Chen and M.C. Bernard

The Garrett Corp., Los Angeles, CA., J. Aircraft, 13 (11), pp 911-918 (Nov 1976) 8 figs, 25 refs

Key Words: Aircraft, Taxiing effects, Pavement roughness

This paper presents a general method of describing both nonstationary and stationary roughness experienced by an aircraft taxiing on ground.

77-791

Aircraft Configuration Noise Reduction. Volume 1. Engineering Analysis

D.G. Dunn, L.M. Butzel, A. DiBlasi, L. Filler and L.D. Jacobs

Boeing Commercial Airplane Co., Seattle, WA., Rept. No. D6-42849-1, FAA/RD-76/76-1, 412 pp (June 1976) (see also Vol. 2, AD-A030 656)

AD-A030 655/5GA

Key Words: Aircraft noise, Noise reduction, Jet engines, Jet noise, Geometric effects

This report discusses use of wing and fuselage structures as noise barriers for shielding aircraft engine noise from the community. The report concerns use of favorable aircraft configurations for community noise reduction of turbojet and turbofan powered aircraft.

77-792

Concorde - Community Noise

J.H. Hay

British Aircraft Corp., SAE Paper No. 760898, 12 pp, 10 figs, 4 refs

Key Words: Aircraft noise, Noise reduction

This paper presents a brief description of the special problems encountered in devizing and developing silencing treatments for a supersonic transport aircraft, and the extensive research and development effort involved. *It outlines the* methods adopted and the development programs involved in the Concorde project. In the course of this work, it was found that static noise tests are not a reliable basis for in-flight noise prediction. The main noise flight tests of the prototype and production aircraft which demonstrated the community noise levels are summarized, and the public response to the first months of in-service operations is indicated.

77-793

Effective Perceived Noise Level Versus Distance Curves for Civil Aircraft

D.E. Bishop, J.F. Mills and J.N. Backmann
Bolt Beranek and Newman, Inc., Cambridge, MA.,
Rept. No. BBN-2747-R, 71 pp (Feb 1976)
PB-257 761/7GA

Key Words: Aircraft noise, Acoustic measurement

This report provides effective perceived noise level (EPNL) data for civil aircraft in a form useful for noise exposure forecast (NEF) calculations. The EPNL noise data are presented in graphical and tabular form; the report also summarizes the data sources and technical analyses used in developing the noise data. A companion report presents sound exposure level (SEL) data for use in day-night level (Ldn) calculations. Noise data are included for all major current U.S. civil transport and business jet aircraft and for most general aviation aircraft. Data are provided for possible retrofit of low bypass ratio (LBPR) turbofan transport aircraft with acoustically lined nacelles.

77-794

Effects of Noise Reduction on Characteristics of a Tilt-Rotor Aircraft

J. Gibs, W.Z. Stepniewski and R. Spencer
Boeing Vertol Co., Philadelphia, PA.,
J. Aircraft, 13 (11), pp 919-925 (Nov 1976) 13 figs, 8 refs

Key Words: Aircraft, Noise reduction, Design techniques

The reduction of far-field acoustic signature through modification of tip speed, number of blades, disk loading, and rotor blade area was examined using a tilt-rotor aircraft as a baseline configuration.

BRIDGES

(Also see No. 664)

77-795

Dynamic Characteristics of Cable-Stayed Girder Bridges

S. Komatsu and M. Kawatani
Dept. of Civil Engrg., Osaka Univ., Osaka, Japan,
Tech. Rept. Osaka Univ., 26 (1276-1307), pp 329-342 (Mar 1976) 10 figs, 12 refs

Key Words: Bridges, Cable stiffened structures, Moving loads

In this paper, the dynamic characteristics of cable-stayed girder bridges, involving their free vibration and dynamic response to a moving load, are theoretically investigated. The dynamic increment factors of deflection and bending moment in a main girder subjected to a traffic load are calculated from a practical point of view. To verify the rationality of a theory and an analytical procedure at the present study, the theoretical results are compared with the experimental ones obtained by dynamic field tests on Toyosato Bridge which is a cable-stayed girder bridge. The effect of a parameter of cable stiffness on the characteristics of the free vibration, and that of parameters of nondimensional velocity of a vehicle as well as on the dynamic increment factors are discussed in this study. The impact fractions in the Japanese Specification of Highway Bridges are investigated comparing with the dynamic increment factors calculated herein.

BUILDING

(Also see Nos. 664, 686, 687, 765)

77-796

Coupled Lateral Torsional Response of Buildings to Ground Shaking

C.L. Kan and A.K. Chopra
Earthquake Engrg. Res. Center, California Univ., Berkeley, CA.,
Rept. No. EERC-76-13, 179 pp (May 1976)
PB-257 907/6GA

Key Words: Buildings, Torsional response, Seismic response, Earthquake response

This study of earthquake response of buildings for which the lateral motions are coupled with the torsional motion is presented in three parts. The elastic response of torsionally coupled one-story buildings to earthquake ground motions, characterized by idealized shapes for the response spectrum, is studied. A simple procedure is developed for the analysis of the elastic response of a particular class of torsionally coupled multistory buildings to earthquake ground motion, characterized by smooth response spectra. With the aid of perturbation analysis of vibration frequencies and mode shapes it is shown that any lower vibration mode of a torsionally coupled building may be approximated as a linear combination of three vibration modes of the corresponding torsionally uncoupled system.

77-797

Nonlinear Inelastic Dynamic Analysis with Soil-Flexibility in Rocking

A.L. Unemori and R.V. Whitman

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. R76-13, NSF/RA-760193, 223 pp (Feb 1976)

PB-256 794/9GA

Key Words: Seismic design, Buildings, Multistory buildings, Rigid foundation, Elastic foundation, Computer programs

This report compares the dynamic response of a building on a rigid foundation designed for earthquakes to the dynamic response of the same building on a nonlinear inelastic flexible foundation. A 17-story reinforced concrete shear wall apartment building was placed on each one of two limiting cases of clay soils. Foundation systems were designed for each soil profile according to existing codes, and moment-rotation relationships for each foundation system were generated. An existing dynamic response computer program was modified to incorporate the predicted moment-rotation characteristics of the foundations. Response of the building on both flexible foundation systems were compared to the response of that building on a rigid foundation, and significant differences identified.

77-798

Studies on the Inelastic Dynamic Analysis and Design of Multi-Story Frames

W.H. Luyties, III, S.A. Anagnostopoulos, and J.M. Biggs

Constructed Facilities Div., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. R76-29, 197 pp (July 1976) (Also see report dated Feb 1976, PB-253 188)

PB-256 540/6GA

Key Words: Multistory buildings, Earthquake response, Computer programs

The inelastic dynamic response of plain frames subjected to earthquake loadings is studied. A sophisticated computer program, FRIEDA, is used for the time integration of the nonlinear equations of motion. First, two models of nonlinear member behavior are compared: the single and the dual component model. Both have been used in the past in nonlinear dynamic analysis studies. Then two real buildings, designed following the ATC-2 procedures, are analyzed for an artificial motion matching the design spectrum. Comparisons between results from modal analysis with inelastic response spectra and those obtained using FRIEDA are made and tentative conclusions are drawn. Finally, the use of inelastic spectra in deisgn is further studied for some other cases.

77-799

Dynamic Response Characteristics of Reinforced Concrete Structures

S.A. Freeman, C.K. Chen, and R.M. Czarnecki

Research Div., John A. Blume and Assoc., San Francisco, CA, Rept. No. CONF-760307-3, 11 pp (1976)

Sponsored by ERDA

N76-31580

Key Words: Multistory buildings, Concrete construction, Structural response, Underground explosions, Damage prediction

A program of vibration investigations of two identical four-story reinforced concrete test structures which were constructed in 1965 at the Nevada Test Site is summarized. These investigations were conducted as part of a structural response program associated with the detonation of underground nuclear explosions. The structures were built to obtain experimental data on the dynamic response characteristics of high-rise concrete buildings, ultimately leading to the development of improved techniques for predicting damage and response to ground motion. Information is included on the four-story test structure, test equipment and methods, methods of response data analysis, and comparison of calculated and measured dynamic response of reinforced concrete structure.

77-800
Wind Response of the Interama Tower of the Sun

K.G. Medearis, J.A. Peterka, and J.E. Cermak
Colorado State Univ., Fort Collins, CO 80523,
Computers and Struc., 6 (6), pp 503-509 (Dec 1976) 12 figs, 17 refs

Key Words: Towers, Cables, Wind-induced excitation, Wind tunnel tests, Mathematical models

The proposed Interama Tower of the Sun is an 830 ft. high tower supported by 168 guy cables with a skyhouse located between the 650 and 740 ft. levels. The tower was to be located approximately 5 miles north of Miami, FL. The site is flat open land, only a few feet above sea level, located a short distance inland from the seacoast -- sufficiently close that no reduction in hurricane wind magnitude due to landfall can be allowed. A study was undertaken to determine overall loads and local pressures by means of wind-tunnel tests, and to determine the dynamic response of the tower to wind loads by means of computer simulation. Wind-tunnel modeling was used to obtain overall wind loading on the tower, to investigate possible vortex shedding phenomena, and to obtain local pressures on the skyhouse and legs. The computer simulation used to determine dynamic response modeled primary structural components of the tower as well as the guy cables, the latter introducing geometric nonlinearity into the model. Appropriate beam-column and cable elements were utilized to represent the structure, with wind loading being considered on all elements.

CONSTRUCTION
(See No. 755)

EARTH
(Also see No. 664)

77-801
Dynamic Analysis of an Arch Dam Subject to Forced Vibrations

R. Priscu, A. Popovici, D. Stematiu, and L. Ilie
Civil Engrg. Institute, Bucharest, Romania,
Mécanique Appliquée, 21 (2), pp 309-317 (1976) 9 figs, 7 refs

Key Words: Dams, Hydroelectric power plants, Vibration response

During the Tarnitza power plant operation, vibrations in the dam body occurred simultaneously with the turbine operation. The analysis of the structure response records has pointed out the hydraulic nature of the phenomenon. Assuming several hypotheses for the source of excitation, the response displacements and accelerations have been obtained from a mathematical model and, accordingly, the dynamic stresses.

FOUNDATIONS
(Also see No. 824)

77-802
Torsional Response of Rigid Embedded Foundation

R.J. Apsel and J.E. Luco
Dept. of Applied Mechanics and Engrg. Sci., Univ. of California, La Jolla, CA,
ASCE J. Engr. Mech. Div., 102 (EM6), pp 957-970 (Dec 1976)

Key Words: Foundations, Torsional response

A series representation is obtained for the harmonic torsional response of a rigid massless semi-ellipsoidal foundation embedded in an elastic half space and subjected to the action of both an external torque and a plane nonvertically incident SH wave. Numerical results are presented for the torsional impedance function for different embedment ratios over a range of frequencies. Numerical results are also shown for the torsional response of embedded foundations to plane wave excitation with different angles of incidence. It is shown that obilquely incident SH waves may induce a large torsional response of the foundation.

HELICOPTERS
(Also see Nos. 808, 809, 846)

77-803
Evaluation of the Sikorsky "Swastika" Dynamic Vibration Absorber in the H-37A

Army Aviation Test Board, Fort Rucker, AL,
Rept. No. ATBG-DT-AVN-4558, 8 pp (Mar 3, 1959) AD-A029 763/0GA

Key Words: Helicopters, Vibration absorption (equipment)

An evaluation of the Sikorsky "Swastika" vertical-lateral vibration absorber was made to determine if this equipment is suitable as a permanent fix by significantly reducing the inherent five times rpm vibration encountered in the cockpit of the H-37A Helicopter.

77-804

Anti-Resonant Isolation for Hingeless Rotor Helicopters

W.E. Hooper and R.A. Desjardins

Boeing Vertol Co., SAE Paper No. 760893, 12 pp, 24 figs, 13 refs

Key Words: Vibration isolators, Helicopters, Rotor-induced vibration

An isolation system has been developed for hingeless rotor helicopters which has been demonstrated to be extremely effective in preventing rotor induced vibration from reaching the airframe. Named IRIS (Improved Rotor Isolation System) the system has been in development for 3 years and was first flown and is currently being demonstrated on a BO-105 helicopter. A similar system has been installed in a Company-owned UTTAS helicopter and is presently being developed through flight testing. This paper describes some of the analytical and bench testing background of both IRIS installations and presents latest available flight data.

77-805

Determination of the Dynamic Characteristics of a Helicopter by the Branch-Modes Method

H. Loiseau and J. Nicholas

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1975-1 (ESA-TT-232) Dec. 1975, pp 61-81 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, No. 1975-1, Jan-Feb 1975, pp 35-44, N76-31180)

N76-31184

Key Words: Helicopters, Branch mode technique

Dynamic characteristics of a helicopter structure with a moving rotor are determined by using the branch modes method. The base, rotor head, and blades were from low damping homogenous materials with rigid or flexible connections having no dissipating hinge points. Test conditions were such that the unsteady aerodynamic forces on the blades were either zero or negligible. The mechanical properties of the model were linear and reproducible. The experiments allow an estimation of the precision required to obtain correct calculations results and show the validity limits of the method if applied to an actual helicopter.

77-806

On the Use of Branch Modes for the Calculation of Helicopter Structural Dynamic Characteristics

C.T. Tran, W. Twomey, and R. Dat

European Space Agency, Paris, France, In: La Rech. Aerospatiale, Bi-monthly Bull. No. 1973-6 (ESA-TT-308) July 1976, pp 51-80 (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, Paris, no. 1973-6, Nov-Dec 1973, pp 337-354, N76-31187)

Sponsored by the Soc. Natl. Ind. Aerospatiale

N76-31192

Key Words: Helicopters, Normal modes, Branch mode technique

The dynamic characteristics of the complete structure, including fuselage and rotor, are determined from the normal branch modes which characterize separately the fuselage and the blades. The solutions define natural vibration modes which vary with the blade rotational speed. The results obtained on a helicopter model are in agreement with the experiments.

77-807

The Effect of Helicopter Main Rotor Blade Phasing and Spacing on Performance, Blade Loads and Acoustics. Final Report

S.T. Gangwani

Systems Research Labs., Inc., Newport News, VA, Rept. No. NASA-CR-2737; SRL-3169-0014, 100 pp (Sept 1976)

N76-32124

Key Words: Helicopter rotors, Helicopter noise

The performance, blade loads, and acoustic characteristics of a variable geometry rotor (VGR) system in forward flight and in a pullup maneuver were determined by the use of existing analytical programs. The investigation considered the independent effects of vertical separation of two three-bladed rotor systems as well as the effects of azimuthal spacing between the blades of the two rotors. The computations were done to determine the effects of these parameters on the performance, blade loads, and acoustic characteristics at two advance ratios in steady-state level flight and for two different g pullups at one advance ratio. To evaluate the potential benefits of the VGR concept in forward flight and pullup maneuvers, the results were compared as to performance, oscillatory blade loadings, vibratory forces transmitted to the fixed fuselage, and the rotor noise characteristics of the various VGR configurations with those of the conventional six-bladed rotor system.

ISOLATION

(Also see Nos. 654, 803, 841)

77-808

Helicopter Rotor Isolation Evaluation Utilizing the Dynamic Antiresonant Vibration Isolator

R. Jones and J.H. McGarvey

Kaman Aerospace Corp., SAE Paper No. 760894, 20 pp, 14 figs, 2 refs

Key Words: Dynamic Antiresonant Vibration Isolator (DAVI), Helicopter rotors, Rotor induced vibrations, Helicopters

Rotor isolation programs utilizing the Dynamic Antiresonant Vibration Isolator (DAVI) are reported. A summary of the analytical, full scale shake test and flight test rotor isolation programs are discussed.

77-809

Isolation of Rotor Induced Vibration with the Bell Focal Pylon-Nodal Beam System

T.M. Gaffey and R.W. Balke

Bell Helicopter Textron, Fort Worth, TX, SAE Paper No. 760892, 10 pp, 18 figs, 3 refs

Key Words: Vibration isolators, Helicopters, Rotor-induced vibration

The technical design considerations of tuning the NODAMATIC system for isolation over a wide rpm range, minimization of system weight, redundancy and crashworthiness, and the influence of the isolation system on rotor stability are discussed. Mechanical design requirements for the system are also discussed. The paper concludes with a discussion of design requirements for an isolation system that could provide the helicopter with a "jet smooth" ride.

METAL WORKING AND FORMING

77-810

An Investigation of Computer Control of Machining Chatter

T.L. Subramanian, M.F. DeVries, and S.M. Wu

Metalworking Section, Battelle Columbus Labs., Columbus, OH, J. Engr. Indus., Trans. ASME, 98 (4), pp 1209-1214 (Nov 1976) 8 figs, 7 refs

Key Words: Machining, Chatter, Automatic control

Based on stochastic process modeling, a scheme has been developed for the detection and control of machining chatter. The range of the tool vibration signal is computed by a hybrid computer and compared with permissible limits to exercise automatic change of the speed and feed rate. The control scheme was evaluated for its adaptability and effectiveness by forcing a chatter condition and subjecting the process to computer control. The scheme is sensitive to process variables.

PRESSURE VESSELS

77-811

Characteristics of a Magnetic Rotor Bearing for Active Vibration Control

G. Schweitzer and R. Lange

Technische Universität Munchen, Institut fuer Mechanik, Munich, Germany, In: Conf. on Vibrations in Rotating Machinery, The Inst. of Mech. Engrs., Univ. of Cambridge, Sept. 15-17, 1976, Paper No. C239, 6 pp, 10 figs, 9 refs

Key Words: Rotors, Vibration control, Active isolation, Bearings, Electromagnetic properties

An electromagnetic bearing can be used very effectively for the vibration control of a rotor. In order to integrate the bearing into an overall rotor-bearing design the bearing has to be considered as the actuator within a control loop, with preferably linear characteristics. This linear relation between control force and generating control current is derived analytically and experimentally. Dynamic properties and disturbing effects are taken into account. The bearing is described by its multiple input-multiple output characteristic. Its application within the control loop for an active bearing is demonstrated.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 712, 718)

77-812

Seismic Analysis of a Reactor Coolant Pump by the Response Spectrum Method

A.P. Villasor, Jr.

Electro-Mechanical Div., Power Systems Co., Westinghouse Electric Corp., Cheswick, PA 15024, Nucl. Engr. Des., 38 (3), pp 527-542 (Sept 1976) 5 figs, 6 refs

Key Words: Pumps, Nuclear reactors, Seismic response, Computer programs

A seismic analysis is performed on nuclear steam supply systems (NSSS) by the response spectrum method in ANSYS, with seismic velocity as the input excitation parameter. The model is excited by a set of three orthogonal spectra. For each load excitation, the modal displacements, forces and moments are computed at each node. A post-run subroutine calculates the absolute sum of nodal response quantities at each mode for one horizontal and the vertical seismic excitations. The resultant modal values are then combined using the square root of the sum of the squares (RSS) to record the final values: SSE X - Y and SSE Y - Z. Nodal stresses are computed; absolute displacements are reviewed for selected nodes along the model branches. The relative displacements at bearings and labyrinths are determined. Finally, the accelerations of nodes previously chosen are found. This paper assesses the effects of a given seismic excitation on the overall structural integrity of an RCP. The in-depth analysis has found the RCP adequate to withstand the imposed seismic loading. All component stresses are within the applicable faulted criteria and the relative movements between closely mated parts fall inside their nominal clearance limits.

77-813

Silencing Experience with a Large Gas Turbine

M.W. Surowiec

Environmental Elements Corp., SAE Paper No. 760908, 12 pp, 14 figs, 2 refs

Key Words: Gas turbines, Noise reduction

An existing silencing system, designed for a residential criterion and which at a later date had its low frequency requirements upgraded, is discussed. The original design steps and test results are reviewed and the testing and design work necessary for the low frequency criterion to be accomplished are presented.

77-814

On the Dynamics of Compressor Surge

D.H. McQueen

Dept. of Building Acoustics, Chalmers Univ. of Technology, Gothenburg, Sweden, J. Mech. Engr. Sci., 18 (5), pp 234-238 (Oct 1976) 4 figs, 4 refs

Key Words: Compressors, Surges, Fluid-induced excitation

The one-dimensional equations of surge in centrifugal compressors are solved graphically for the pressure head and mass flow rate as functions of time for a variety of situations, and the results are discussed in terms of the acoustical properties of the external piping. Two important parameters affecting the nature of the surge limit cycle are found to be simply related to the acoustic capacitance and acoustic inductance of the system.

77-815

The CFM56 Turbofan Engine. Progress in the Reduction of Engine Noise

J.P. Bernard and P. Raffy

Kanner (Leo) Associates, Redwood City, CA, Rept. No. NASA-TT-F-17176, 37 pp (Aug 1976) (Engl. transl. of conf. paper from Coc. Natl. d'Etude et de Construction de Moteurs d'Aviation, Paris)
N76-31230

Key Words: Turbofan engines, Engine noise, Noise reduction

The CFM56 is a double-body, dual flow turbofan engine. Test facilities for examination of the aerodynamic internal and engine noise characteristics of the turbofan are described. An installation for the determination of the efficacy of acoustic attenuation treatments on the engine is included. Maximum engine noise is plotted as a function of thrust, and noise spectra on landing approach, takeoff, and intermediate flight are presented.

77-816

Theoretical Analysis of Unsteady Supersonic Flow Around Harmonically Oscillating Turbofan Cascades

J.E. Caruthers

Ph.D. Thesis, Georgia Institute of Technology, 157 pp (1976)
UM 76-29,354

Key Words: Turbofans, Fluid-induced excitation

A solution method is developed for the supersonic cascade problem utilizing a finite-difference/pressure-amplitude-function technique. The method developed is valid for both the supersonic and subsonic leading edge problems, although developed specifically for the latter problem. Excellent agreement is obtained with existing solutions in all the limiting cases and the cascade results are compared with some recently published results using other methods. A parametric study is given of a typical supersonic cascade configuration.

77-817

Predicting the Sound Emission from Air-Conditioning and Ventilating Systems

D.J. Croome

Dept. of Civil Engrg., Univ. of Technology, Loughborough, Leicestershire, Great Britain, Appl. Acoust., 9 (4), pp 303-315 (Oct 1976) 5 figs, 3 refs

Key Words: Air conditioning equipment, Noise prediction

Research has been carried out to investigate the nature and level of sound emitted in rooms served by airconditioning systems. An initial survey measured the sound spectra in 74 university lecture rooms. Fans, motors, vee-belt drives and an airflow system were then installed to serve one lecture room.

77-818

Design and Development of Cooling Fans for Internal Combustion Engines

D. Esche

Koln, Germany, MTZ Motortech. Z., 37 (10), pp 399-403 (Oct 1976) 7 figs, 7 refs
(In German)

Key Words: Cooling fans, Internal combustion engines, Noise generation

This article discusses development work concerning aerodynamic and acoustic problems of cooling fans for air-cooled internal combustion engines. For single-stage axial fans with guide vanes, optimum design ranges and comparisons for installation of front or rear guide vanes are given. Fan noise can be calculated in advance from aerodynamic parameters.

77-819

Noise Mechanism Separation and Design Considerations for Low Tip-Speed, Axial-Flow Fans

R.E. Longhouse

Fluid Dynamics Research Dept., Research Laboratories, General Motors Corp., Warren, MI 48090, J. Sound Vib., 48 (4), pp 461-474 (Oct 22, 1976) 15 figs, 5 refs

Key Words: Fans, Noise generation

Noise and performance tests were conducted on low tip-speed, half-stage axial flow fan such as is used in automotive applications. The tests were conducted in a free-field environment. Various degrees of rotational noise due to inflow distortion were produced by installing circular rods upstream from the fan. The fan back pressure and speed were varied during the tests. The tests determined the general characteristics of rotational and non-rotational noise as functions of flow coefficient and fan speed.

77-820

A Theory on the Relationship Between Drive Train Vibration and Belt-Driven Engine Cooling Fan Fatigue Failures

R.C. Bremer, Jr.

Schwitzer Engineered Components, SAE Paper No. 760842, 24 pp, 26 figs

Key Words: Fans, Crankshafts, Torsional vibrations

Fatigue failures observed in a belt-driven engine cooling fan indicated the presence of significant vibration activity. A testing and analysis program was undertaken in an effort to measure the fan vibration characteristics in a vehicle environment, and relate these characteristics to some known source of excitation.

RAIL

(See Nos. 675, 676, 677)

REACTORS

(Also see Nos. 703, 704, 705, 706, 768, 785, 812)

77-821

Seismic Model of the Gas Cooled Fast Breeder Reactor Core Support Structure

L.E. Penzes

General Atomic Co., San Diego, CA 92138, Nucl. Engr. Des., 38 (3), pp 543-554 (Sept 1976) 9 figs, 11 refs

Key Words: Nuclear reactor components, Seismic response, Modal analysis

A modeling technique for the seismic analysis of the core support structure of a gas-cooled fast breeder reactor is developed. The core support structure consists of the support cylinder and a perforated grid plate to which 265 fuel and blanket elements are clamped as cantilevered beams. The analysis of the core support structure consist of three steps: analysis of the grid plate, analysis of the core elements, and modal synthesis.

77-822

Bell-Ring Vibration Response of Nuclear Containment Vessel with Attached Masses Under Earthquake Motion

K. Shiraki, Y. Kajimura, H. Shibata and T. Kawakatsu
Takasago Technical Institute, Mitsubishi Heavy Industries, Ltd., Takasago, Japan, Nucl. Engr. Des., 38 (3), pp 475-493 (Sept 1976) 22 figs, 4 refs

Key Words: Nuclear power plants, Seismic response, Bells, Rings

Approximate seismic analyses of bell-ring type vibration using the natural mode shapes of unweighted perfect axisymmetric shell are advocated on the assumption that the effect of the attached mass on their natural modes might be very small. In this paper we show the seismic response analysis of the bell-ring type vibration coupled with the beam-type vibration through the attached masses with the new consideration. These results show good agreement between the theoretical calculation and the experiment.

77-823

Nonlinear Dynamic Response of Reactor Containment

T. Takemori, K. Sotomura and M. Yamada
Dept. of Structural Engrg., Taisei Corp., Chuo-ku, Tokyo 104, Japan, Nucl. Engr. Des., 38 (3), pp 463-474 (Sept 1976) 20 figs, 7 refs

Key Words: Nuclear power plants, Seismic response, Computer programs

The purpose of this paper is to present the outline of this program and to discuss the problems of nonlinear response of structures. A reactor containment (reactor building) of a PWR plant was modeled. This building consists of three components: a concrete internal structure, a steel containment vessel and a concrete outer shield wall. These components rest on a rigid foundation mat. They were modeled with a lumped mass model coupled on the foundation.

77-824

Aseismic Design of Turbine Houses for Nuclear Power Plants

R. Danisch and M. Labes
Kraftwerk Union AG, Kraftwerktechnik, D-852 Erlangen, Germany, Nucl. Engr. Des., 38 (3), pp 495-501 (Sept 1976) 11 figs, 3 refs

Key Words: Nuclear power plants, Seismic design, Foundations

Low-tuned turbine foundations with helical-spring-support are discussed with respect to special problems with the aseismic design.

77-825

Earthquake Design of Nuclear Power Plants

H.J. Kaestle
Inst. fuer Reaktorsicherheit, Technischer Uerberwachungs - Verein Rheinland, e.V., Cologne, West Germany, In: Roy. Neth. Meteorol. Inst. on Earthquake Risk for Nucl. Power Plants (Jan 1976), pp 157-163, N76-31787)
N76-31807

Key Words: Nuclear power plants, Seismic design, Earthquake resistant structures

The earthquake risk to nuclear power plants and the problems involved in protecting nuclear power plants against earthquakes are discussed. Methods for calculating the maximum loadings for buildings, structures, and components are reviewed. They include the response spectrum modal analysis, the time history modal analysis, and the time history analysis.

77-826

Generation of Artificial Time-Histories, Rich in All Frequencies, From Given Response Spectra

S. Levy and J.P.D. Wilkinson
Power Generation & Propulsion Lab., General Electric Company, Schenectady, NY 12345, Nucl. Engr. Des., 38 (2), pp 241-251 (Aug 1976) 10 figs, 7 refs

Key Words: Nuclear power plants, Seismic response

An objective of this paper is to present a method of synthesizing time-histories from a given design response spectrum. The method to be described in this paper allows the generation of time-histories with all frequencies in the spectrum. This is achieved by choosing a large number of closely-spaced frequency points such that the half-power points of adjacent frequencies overlap. Examples are given concerning seismic design response spectra, and a number of points are discussed concerning the effect of frequency spacing on convergence.

77-827
Seismic Design of Nuclear Power Plants -- An Assessment

G.E. Howard, P. Ibanez and C.B. Smith
Applied Nucleonics Co., Inc., Santa Monica, CA 90404, Nucl. Engr. Des., 38 (3), pp 385-461 (Sept 1976) 18 figs, 256 refs

Key Words: Nuclear power plants, Seismic design

This paper presents a review and evaluation of the design standards and the analytical and experimental methods used in the seismic design of nuclear power plants with emphasis on United States practice. Three major areas were investigated: soils, siting, and seismic ground motion specification; soil-structure interaction; and the response of major nuclear power plant structures and components. The purpose of this review and evaluation program was to prepare an independent assessment of the state-of-the-art of the seismic design of nuclear power plants and to identify seismic analysis and design research areas meriting support by the various organizations comprising the 'nuclear power industry'. Criteria used for evaluating the relative importance of alternative research areas included the potential research impact on nuclear power plant siting, design, construction, cost, safety, licensing, and regulation.

77-828
Development and Use of Seismic Instructure Response Spectra in Nuclear Plants

M. Stoykovich
Gibbs and Hill, Inc., New York, NY 10001, Nucl. Engr. Des., 38 (2), pp 253-266 (Aug 1976) 10 figs, 17 refs

Key Words: Nuclear power plants, Seismic design

This paper encompasses methods for the development of structure response spectra as well as the use of these spectra in the seismic design and analysis of nuclear plant components. The time history modal analysis method is described.

77-829
Scram and Nonlinear Reactor System Seismic Analysis for a Liquid Metal Fast Reactor

A. Morrone, A.N. Nahavandi and W.G. Brussalis
Advanced Reactors Div., Westinghouse Electric Corp., Madison, PA 15663, Nucl. Engr. Des., 38 (3), pp 555-566 (Sept 1976) 9 figs, 4 refs

Key Words: Nuclear reactor components, Seismic response

This paper presents the analysis and results for a liquid metal fast reactor system which was analyzed for both scram times and seismic responses such as bending moments, accelerations and forces. The reactor system was represented with a one-dimensional nonlinear mathematical model with two degrees of freedom per node (translational and rotational). The model was developed to incorporate as many reactor components as possible without exceeding computer limitations.

77-830
Three-Dimensional Dynamic Response Modeling of Floating Nuclear Plants Using Finite Element Methods

H.W. Johnson, A.K. Vaish, F.L. Porter and R. McGeorge
EDS Nuclear, Inc., San Francisco, CA 94104, Nucl. Engr. Des., 38 (3), pp 503-510 (Sept 1976) 14 figs, 5 refs

Key Words: Nuclear power plants, Floating structures, Dynamic response, Finite element technique

A modeling technique which can be used to obtain the dynamic response of a floating nuclear plant (FNP) moored in an artificial basin is presented. Hydrodynamic effects of the seawater in the basin have a significant impact on the response of the FNP are included. A three-dimensional model of the platform and mooring system (using beam elements) is used, with the hydrodynamic effects represented by added mass and damping.

RECIPROCATING MACHINE

(Also see Nos. 729, 818, 832)

77-831
Quietening a Quiet Engine - The RB211 Demonstrator Programme

M.J.T. Smith
Rolls-Royce (1971), Ltd., SAE Paper No. 760897, 20 pp, 26 figs, 6 refs

Key Words: Engine noise, Noise reduction

Against the background of the RB211/Lockheed L1011 development programme, which led to the certification of the quietest modern jet aircraft then entering service, Rolls-Royce determined to establish the realistic potential for further noise reductions on a high bypass ratio engine. Following a two year feasibility study the programme was launched in mid 1972 based around a standard production RB 211 engine. This paper summarizes the important findings, highlights areas in which research and development should be concentrated for noise reduction in high bypass ratio jet engines. It presents a judgment of future trends and implications.

77-832

Computation and Measurement of the Vibration Modes of Reciprocating Engines

G. Kuipers

Ingolstadt, Germany, MTZ Motortech. Z., 37 (9), pp 369-372 (Sept 1976) 4 figs, 3 refs

(In German)

Key Words: Motor vehicle noise, Noise reduction, Vibration measurement, Engine noise

This article gives a calculation method for the vibration modes caused by the free forces of a freely vibrating, reciprocating engine, which is assumed to be rigid. Further, a method is given to measure the vibration modes of an engine, which is not dynamically rigid. By comparing the calculated vibration modes with the actual vibration modes measured it is possible to see to what degree the engine vibrations exceed their theoretical minimum and to decide if the engine should be improved.

77-833

Experimental Clean Combustor Program; Noise Measurement Addendum, Phase 2

J.J. Emmerling and K.L. Bekofske

General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-135045; R75AEG147-13-Add, 177 pp (Jan 1976)

N76-31231

Key Words: Combustion engines, Noise measurement

Combustor noise measurements were performed using wave guide probes. Test results from two full scale annular combustor configurations in a combustor test rig are presented.

ROAD

(Also see Nos. 662, 688)

77-834

Seat Movement Relative to the Passenger Compartment -- A Possible Method to Improve Passenger Protection During Frontal Impacts

H.H. Braess

F. Porsche Aktiengesellschaft, Stuttgart, Germany, Vehicle Syst. Dyn., 5 (3), pp 127-145 (Oct 1976) 9 figs, 14 refs

Key Words: Collision research (automotive), Automobile seats

The goal of this study is to prove in a theoretical way that a controlled seat movement relative to the passenger compartment will result in an improvement of passenger deceleration during vehicle frontal impacts.

77-835

A Tentative Criterion for Acceptable Noise Levels in Passenger Vehicles

M.E. Bryan

Dept. of Electrical Engrg., Univ. of Salford, Salford M5 4WT, England, J. Sound Vib., 48 (4), pp 525-535 (Oct 22, 1976) 10 figs, 11 refs

Key Words: Passenger vehicles, Interior noise, Noise measurement

This paper describes the results of the measurement of noise inside a variety of passenger vehicles over the frequency range 2 Hz-16kHz and an attempt to find a satisfactory measure of subjective response.

77-836

Mechanical Design Optimization with Transient Dynamic Response

M.H. Hsiao, E.J. Haug, Jr., and J.S. Arora

Div. of Materials Engrg., Iowa Univ., Iowa City, IA, 111 pp (Apr 1976)

AD-A029 677/2GA

Key Words: Ground vehicles, Optimization, Dynamic response, Steepest descent method

In this report a technique for mechanical design optimization with constraints on transient dynamic response is developed through application of optimal design theory and functional analysis. Several mechanical system problems involving a family of input or environmental excitation functions are solved to illustrate the technique.

77-837

Sound Attenuation Kit for Diesel-Powered Buses

J.C. Berry and D.L. Overgard

Rohr Industries, Inc., Chula Vista, CA, Rept. No. DOT-TSC-OST-76-5, 235 pp (June 1976)

PB-256 828/5GA

Key Words: Buses (vehicles), Noise reduction

This report is intended to provide a reference for manufacturers, owners, and operators to consult for recommendations or instructions on installing a proven noise-reduction kit. It provides an insight into the causes of diesel-powered bus noise and demonstrates an effective means for its reduction. Appendixes give standard noise measurement procedures, acoustic and performance test data on the various design configurations, and service information on sound attenuation kits.

77-838

The Study of Vibrations Generated by the Tracks of Tracked Vehicles

S.M. Lee

Keweenaw Research Center, Michigan Technological Univ., Houghton, MI, 52 pp (July 1976)

AD-A030 042/6GA

Key Words: Tracked vehicles, Tanks (combat vehicles), Interior vibration, Interior noise, Vibration control

This is an analytical study of the vibrations generated by the track of tracked vehicles. A method of analysis is derived from the technique of receptance calculation. Combination of these results can be used to predict optimum conditions under which the vibration of a prescribed frequency can be minimized. Actual vehicles operating under various terrain conditions will be used.

77-839

Experiments in Guideway -- Levitation Vehicle Interaction Dynamics

J.F. Wilson

Dept. of Civil Engrg., Duke Univ., Durham, NC, Rept. No. FRA/ORD-76/259, 88 pp (Jan 1976)

PB-257 941/5GA

Key Words: Tracked vehicles, Ground effect machines, Interaction: vehicle-guideway

This investigation involves the design and interpretation of laboratory-scale dynamic experiments of vehicles traversing multiple-span or cable-stayed guideways.

77-840

Truck Noise I-D. Empirical Model for Predicting In-Service Truck Tire Noise Levels

R. D. Kilmer, W. A. Leasure, Jr., D. M. Corley, D. E. Mathews, and C. O. Shoemaker

National Bureau of Standards, Washington, D.C. Rept. No. DOT/TST-76T-5, 68 pp (July 1976)

PB-257 786/4GA

Key Words: Truck tires, Noise measurement, Noise prediction

This report discusses the basic assumptions and necessary input data for a DOT/NBS developed empirical model which utilizes the certification test results to predict in-service noise levels. The usefulness and expected accuracy of the predictive model are shown through a comparison of measured versus predicted maximum A-weighted sound levels for a variety of truck/tire combinations.

77-841

The Influence of the Suspension System on Motorcycle Weave Mode Oscillations

R.S. Sharp

Dept. of Mech. Engrg., Univ. of Leeds, Leeds LS2 9JT, England, Vehicle Syst. Dyn., 5 (3), pp 147-154 (Oct 1976) 3 figs, 5 refs

Key Words: Motorcycles, Suspension systems (vehicles)

The vertical motions of a large motorcycle on its tires and suspension system are analyzed, and the possibility of one of the natural frequencies being close to that of the lateral oscillation, the weave mode, is demonstrated. Interactions between the vertical and lateral modes, and the implications for motorcycle design and development are discussed.

77-842

Control of Motorcycle Noise, Volume 1. Technology and Cost Information

S.R. Skale and B.H. Sharp

Wyle Labs., El Segundo, CA, Rept. No. EPA/550/9-74/001A, 132 pp (June 1974)

PB-257 727/8GA

Key Words: Motorcycles, Motor vehicle noise, Noise reduction

This document contains information useful for the development of noise emission standards for motorcycles. Topics covered include information on motorcycle construction, noise characteristics of models currently on the market, and noise reduction techniques and costs necessary to achieve specified noise levels.

77-843

Control of Snowmobile Noise, Volume 1. Technology and Cost Information

B.A. Davy and B.H. Sharp
Wyle Labs., Huntsville, AL, Rept. No. EPA/550/9-74/003-A, 63 pp (June 1974)
PB-257 680/9GA

Key Words: Snowmobiles, Engine noise, Noise reduction

This document contains information useful for the development of noise emission standards for snowmobiles. Topics covered include information on snowmobile construction, noise characteristics of models currently on the market, and noise reduction techniques and costs necessary to achieve specified noise levels.

ROTORS

(Also see Nos. 718, 808, 809, 811)

77-844

Instabilities of an Asymmetric Rotor with Asymmetric Shaft Mounted on Symmetric Elastic Supports

D. Ardayfio and D.A. Frohrib
Mech. Engrg., Faculty of Engrg., Univ. of Science and Technology, Kumasi, Ghana, J. Engr. Indus., Trans. ASME, 98 (4), pp 1161-1175 (Nov 1976) 3 figs, 11 refs

Key Words: Rotors, Elastic foundations, Stability

Instabilities of an asymmetric rotor with asymmetric shaft mounted on symmetric elastic supports are considered. The periodic coefficients which appear in the system equations are eliminated by transformation to a rotating coordinate system rotating at the constant angular speed of the rotor. The unstable speed regions are identified by studying the nature of the roots of the characteristic equation. The combined effects of the inertia and shaft asymmetry and the flexible supports are appreciated by representative numerical examples. The results are presented in three-dimensional diagrams to show how the asymmetry parameters affect the unstable speed regions for known values of support stiffness.

77-845

Analysis of Flexible Rotor Whirl and Whip Using a Realistic Hydrodynamic Journal Bearing Model

S.T. Myrick, Jr. and H.G. Rylander
Engrg. R & D Div., E. I. duPont de Nemours and Co., Wilmington, DE, J. Engr. Indus., Trans. ASME, 98 (4), pp 1135-1144 (Nov 1976) 12 figs, 23 refs

Key Words: Rotor-bearing systems, Whirling

An analytical method has been developed for the simulation of the transient and steady-state response of flexible rotors supported by realistic incompressible-film hydrodynamic journal bearings. The coupled nonlinear differential equations of rotor motion, formulated as an initial-value problem, are solved in conjunction with a "realistic" Reynolds equation solution which includes finite bearing length, wedge and squeeze films, fluid film cavitation, oil inlet geometry, and eccentricity and tilt (gyroscopics) of the journal. Presented in this paper are some of the results of a numerical and experimental study of rotor whirl using that analytical model. The response of a flexible rotor, for speeds up to the threshold of instability, is demonstrated as a function of disk unbalance and viscous damping. The validity of the analytical model is confirmed by comparison of experimental whirl data with numerical simulations of the response of the test rotor through the critical speed region to the onset of oil whip.

77-846

Radiation Characteristics of Acoustic Sources in Circular Motion

V.J. Virchis and S.E. Wright
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, England, J. Sound Vib., 49 (1), pp 115-128 (Nov 8, 1976) 16 figs, 3 refs

Key Words: Rotary wings, Blades, Noise generation, Computer programs

This paper examines the acoustic properties of periodic unsteady rotor blade forces. An efficient computer program, which retains what is regarded as the essential radiation terms, has been developed to numerically evaluate the radiation equations for sources rotating in a circle. A variety of operating conditions and types of blade loading have been computed; of special interest are the radiation properties of impulsive blade loading at high tip speeds. These computations show an acoustic beaming effect similar to that which is radiated by helicopters in high forward speed flight.

SHIP

(Also see No. 746)

77-847

On the Collision Protection of Ships

N. Jones

Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Nucl. Engr. Des., 38 (2), pp 229-240 (Aug 1976) 2 figs, 48 refs

Sponsored by the National Science Foundation

Key Words: Collision research (ships), Energy absorption, Honeycomb structures

A brief survey of the literature existent on the collision protection of ships is presented herein. An examination of the characteristics of different energy-absorbing methods suggests that honeycomb structures provide a feasible alternative to deck structures which are currently used to achieve the collision protection of ships. Various features of honeycomb panels are explored and a particular structural arrangement which utilizes both sides of a hull and incorporates honeycomb panels is proposed for the collision protection of a ship.

SPACECRAFT

(Also see No. 700)

77-848

Comparison of Modal Test Results: Multipoint Sine Versus Single-Point Random

E.L. Leppert, S.H. Lee, F.D. Day, P.C. Chapman, and B.K. Wada

Jet Propulsion Lab., California Inst. of Technology, SAE Paper No. 760879, 16 pp, 7 figs, 6 refs

Key Words: Spacecraft, Modal tests, Computer programs, Testing techniques

Several software packages have been developed for use with minicomputers to decrease the test schedule and cost of modal surveys. The tests, performed on the Mariner Jupiter/Saturn (MJS) spacecraft, provide an additional comparison of the more traditional multipoint sine dwell and the single-poing random modal test methods.

STRUCTURAL

77-849

On the Dynamics of Bridged Structures

R. Sofronie

Inst. of Civil Engrg., Bucharest, Romania, Mécanique Appliquée, 21 (3), pp 389-404 (1976), 7 figs, 7 refs

Key Words: Structural response, Bridging, Natural vibrations, Wind-induced excitation, Earthquake response

The paper deals with systems of elastical structures bridged at one or more levels. The influence of bridging on natural oscillations is first determined. Then, the response of these structures to impulses of wind and earthquakes is analyzed. The structural damping is evaluated such that all the induced energy be dissipated and the motion remain stable. The analysis emphasizes new properties of the bridged structures.

77-850

Resonant Scattering by a Harbor with Two Coupled Basins

C.C. Mei and U. Unluata

Dept. of Civil Engrg., Massachusetts Institute of Technology, Cambridge, MA 02139, J. Engr. Math., 10 (4), pp 333-353 (Oct 1976) 6 figs, 19 refs

Key Words: Harbors, Resonant frequencies

A harbor with two coupled rectangular basins is subjected to periodic incident waves. Ignoring friction the scattering problem is solved by the method of matched asymptotics for narrow junctions. The example of two identical basins is analyzed in detail for the resonant spectrum and response. It is shown that for certain modes the inner basin is less shielded.

AUTHOR INDEX

TECHNICAL NOTES

J.O. Hallquist and W.W. Feng
On the Specification of Eigenvalues in Vibratory Systems
J. Appl. Mech., Trans. ASME, 43 (2), pp 359-360 (June 1976) 5 refs

T.W. Lee
Transverse Vibrations of a Tapered Beam Carrying a Concentrated Mass
J. Appl. Mech., Trans. ASME, 43 (2), pp 366-367 (June 1976) 2 refs

M.S. Bohn and E.E. Zukoski
Effect of Flow on the Acoustic Reflection Coefficient at a Duct Inlet
J. Acoust. Soc. Amer., 59 (6), pp 1497-1498 (June 1976) 1 fig, 4 refs

G.A. Luz and J.B. Smith
Reactions of Pronghorn Antelope to Helicopter Overflight
J. Acoust. Soc. Amer., 59 (6), pp 1514-1515 (June 1976)

H.R. Radwan and J. Genin
Nonlinear Vibrations of Thin Cylinders
J. Appl. Mech., Trans. ASME, 43 (2), pp 370-372 (June 1976) 9 refs

J. Ramachandran
Large Amplitude Vibrations of Shallow Spherical Shell with Concentrated Mass
J. Appl. Mech., Trans. ASME, 43 (2), pp 363-365 (June 1976) 5 figs, 2 refs

E. Hinton
A Note on a Finite Element Method for the Free Vibrations of Laminated Plates
Intl. J. Earthquake Engr. Struc. Dynam., 4, pp 515-516 (1976) 2 refs

J.T.S. Wang
On the Theories of Ring Vibrations
J. Appl. Mech., Trans. ASME, 43 (3), pp 503-504 (Sept 1976) 3 refs

E. Hinton
Short Communication. A Note on a Thick Finite Strip Method for the Free Vibration of Laminated Plates
Intl. J. Earthquake Engr. Struc. Dynam., 4, pp 511-520 (1976) 1 fig, 5 refs

D.A. Sanchez
An Approximate Periodic Solution of a Weakly Nonlinear Wave Equation
J. Appl. Mech., Trans. ASME, 43 (3), pp 504-505 (Sept 1976) 1 fig, 4 refs

E. Litov
Automatic Frequency Control System for Ultrasonic Pulse Superposition Measurements
Rev. Sci. Instr., 47 (7), pp 880-881 (July 1976) 2 figs, 2 refs

J.A. Walker
Orthogonality Relations for a Class of Linear Vibration Problems
Quart. Appl. Math., 34 (2), pp 207-210 (July 1976) 6 refs

S.M. Pandit, T.N. Goh and S.M. Wu
Modeling of System Dynamics and Disturbance From Paper-Making Process Data
J. Dyn. Syst., Meas. and Control, Trans. ASME, 98 (2), pp 197-199 (June 1976) 1 fig, 11 refs

R.J. Uncles
Numerical Solution of Acoustic Scattering Problems at Intermediate Frequencies
J. Acoust. Soc. Amer., 60 (1), pp 266-267 (July 1976) 1 fig, 5 refs

J.E. Cole, III and I.I. Sarris
Acoustic Power of a Moving Point Source in a Moving Medium
J. Acoust. Soc. Amer., 60 (1), pp 264-266 (July 1976) 14 refs

C.W. Ingram and W.J. Szwarc
Passive Flutter Suppression
J. Aircraft, 13 (7), pp 542-543 (July 1976) 2 figs, 5 refs

MEETING	DATE	LOCATION	CONTACT
	1977 APR		
Lubrication Symposium	11-13	St. Louis, MO	ASME Hq.
American Power Conference, Ill. Inst. Tech.	18-20	Chicago, IL	R.A. Budenholzer, Dir. APC c/o IIT, 10 W. 35th St. Chicago, IL 60616
Design Engineering Conference and Show, ASME	18-20	New York, NY	ASME Hq.
2nd International Conference on Vehicle Structural Mechanics	18-20	Southfield, MI	SAE Hq.
Mini-Conference on Transportation	19-21	Ann Arbor, MI	Highway Safety Research Institute The University of Michigan Ann Arbor, MI 48109 Tele. (313) 764-2168
IES Annual Meeting	24-27	Los Angeles, CA	IES Hq.
Meeting on Wear of Materials	25-27	St. Louis, MO	Prof. K. C. Ludema, Dept. of ME, The University of Michigan Ann Arbor, MI 48109
9th Space Simulation Conference IES-AIAA-ASTM-NASA	26-28	Los Angeles, CA	IES Hq.
International Conference - Tribology	April	Cambridge, MA	Lt. R.S. Miller, Code 211 Office of Naval Research, Ballston Tower No. 1, Arlington, VA 22117 Tele. 692-4421
	MAY		
23rd International Instrumentation Symposium	1-5	Las Vegas, NV	ISA Hq.
Symp. on Fatigue Testing of Weldments	1-6	Toronto, Canada	ASTM Hq., Ms. J.B. Wheeler
Offshore Technology Conference	2-5	Houston, TX	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
Symp. on Statistical Design of Fatigue Experiments	5	Toronto, Canada	ASTM, Ms. J.B. Wheeler
American Helicopter Society Annual National Forum	9-11	Washington, D.C.	American Helicopter Society Lounsbury, Exec. Dir., 30 East 42nd St. New York, NY 10017
National Plant Engineering and Maintenance Show and Conference	9-12	Chicago, IL	Clapp & Poliak Banner & Greif Ltd. 369 Lexington Ave. New York, NY 10017

CALENDAR

MEETING	DATE	LOCATION	CONTACT
	1977 MAY		
31st Annual Technical Conference ASQC	16-18	Philadelphia, PA	R.W. Shearman, ASQC Hq.
Society for Experimental Stress Analysis 1977 Spring Meeting & Exposition	15-20	Dallas, TX	SESA Hq., B. E. Rossi
National Aerospace Electronics Conference	17-19	Dayton, OH	NAECON 140 E. Monument Ave. Dayton, OH 45402
Society of Naval Architects and Marine Engineers 1977 Spring Meeting and STAR Symposium	25-27	San Francisco, CA	A. J. Haskell, Matson Navigation Co. 100 Mission St. San Francisco, CA 94105
6th Canadian Congress of Applied Mechanics	30 May - 3 Jun	Vancouver, Canada	Prof. J.P. Duncan, ME Dept. Univ. of British Columbia Vancouver, BC, Canada
Symposium on Tire Vibration and Noise	May		H. G. Schwartz ASTM Subcommittee F-9.93 on Papers & Symposium E. I. duPont 40 Buchtel Ave. Akron, OH 44308
	JUNE		
Fuels and Lubricants Meeting, SAE	7-9	Tulsa, OK	SAE Hq.
Acoustical Society of America, Spring Meeting	7-10	State College, PA	J. C. Johnson, Appl. Res. Lab. Pennsylvania State University Box 30 State College, PA 16801
National Computer Conference	13-16	Dallas, TX	Ms. P. Isaacson University of Texas Box 688 Richardson, TX 75080
Applied Mechanics Conference, ASME	14-16	New Haven, CT	ASME Hq.
Fluids Engineering Conference	15-17	New Haven, CT	ASME Hq.
4th International Conference on Fracture	19-24	Waterloo, Canada	Prof. T. Kawasaki, Sec. Gen. Int'l. Congress of Fracture c/o Dept. of ME Tohoku University Sendai, Japan
Design Automation Conference	20-22	New Orleans, LA	H. Hayman Box 639 Silver Spring, MD 20901
Symposium on Dynamic Tests on Soil & Rock, ASTM	26 Jun - 1 Jul	Denver, CO	ASTM Hq., Ms. J.B. Wheeler

CALENDAR

MEETING	DATE	LOCATION	CONTACT
	1977 JULY		
Application of New Signature Analysis Technology Conference	24-29	Rendge, NH	Dr. Sanford S. Cole Engineering Foundation Conferences 345 E. 47th St. New York, NY 10017 Tele. (212) 644-7835
	AUG		
Society of Automotive Engineers	8-11	Vancouver, Canada	SAE Hq., A.L. Weldy
	SEPT		
Energy Technology Conference and Exhibit	18-23	Houston, TX	ASME Hq.
Vibrations Conference, ASME	26-28	Chicago, IL	ASME Hq.
	OCT		
NOISE-CON 77	10-12	Hampton, VA	Conference Secretariat *Noise Control Foundation* P.O. Box 3469, Arlington Branch Poughkeepsie, NY 12603 Tele. (914) 462-6719
48th Shock and Vibration Symposium	18-20	Huntsville, AL	Henry C. Pusey, Director The Shock and Vibration Information Center, Code 8404 Naval Research Laboratory Washington, D.C. 20375 Tele. (202) 767-3306
	NOV		
Winter Annual Meeting, ASME	27 Nov-2 Dec	Atlanta, GA	ASME Hq.

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New York, N.Y. 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, N.Y. 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, Ill. 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, N.Y. 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, N.Y. 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, N.Y. 10017

ASME: American Society of Mechanical Engineers
345 E. 47th St.
New York, N.Y. 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, Ill. 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, Wis. 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, Pa. 19103

CCCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, N.Y. 10017

IES: Institute Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, Ill. 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME, Amherst, Mass. 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch,
Poughkeepsie, N.Y. 12603

ISA: Instrument Society of America
400 Stanwix St., Pittsburgh, Pa. 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy, Arlington, Va. 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, Pa. 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, England

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, Conn. 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, N.Y. 10006

SVIC: Shock and Vibration Information Center
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URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, Mass. 02173

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SUMMARY COVER SHEET
48TH SHOCK AND VIBRATION SYMPOSIUM
Huntsville, AL, 18-20 October 1977

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SUMMARY OF SHORT DISCUSSION TOPIC
48TH SHOCK AND VIBRATION SYMPOSIUM
Huntsville, AL, 18-20 October 1977

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